

INSTALLATION RESTORATION PROGRAM

FINAL
REVISION 04

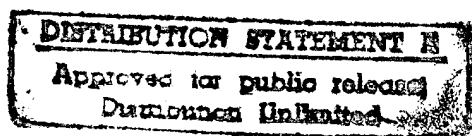
SITE INVESTIGATION REPORT VOLUME 1: SECTIONS 1 THROUGH 6, APPENDIX A

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska

April 1995



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HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM
Environmental Restoration and Waste Management Programs
Oak Ridge, Tennessee 37831-7606
managed by MARTIN MARIETTA ENERGY SYSTEMS, INC.
For the U.S. DEPARTMENT OF ENERGY under contract DE-AC05-84OR21400

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13. ABSTRACT (Maximum 200 words) Site Investigation Report, Volume 1: Sections 1 through 6, Appendix A. A Site Investigation was performed at the 155th Air Refueling Group at Lincoln, NE to evaluate six areas of suspected contamination identified during a Preliminary Assessment. The sites that this investigation were conducted at are: Site 1 - Fuel Farm, POL Storage Area, Site 2 - West End of Old Oak Creek, Site 3 - Former Tank Cleaning/Hazardous Waste Storage Area, Site 4 - Access Road, Dust Control Area, , Site 5 - Army National Guard Oil Storage Area, and Site 6 - Hydraulic Pressure Check Unit Storage Area. The report recommended no further action for Sites 3 through 6 due to low levels or no contamination being found. The report recommended that the portion of Site 2 that is located downstream of Site 1 should be included in Site 1.				
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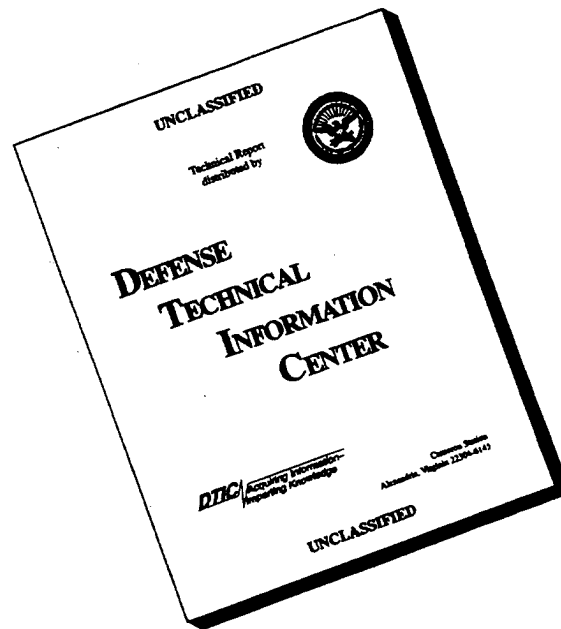
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FINAL

SITE INVESTIGATION REPORT

REVISION 04

VOLUME 1: SECTIONS 1 THROUGH 6, APPENDIX A

**155TH AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA**

Prepared for

**NATIONAL GUARD BUREAU
ANDREWS AIR FORCE BASE, MARYLAND**

April 1995

Prepared by

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Parsons Engineering Science, Inc.
1700 Broadway, Suite 900
Denver, Colorado 80290

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EXECUTIVE SUMMARY

This report presents the results of the Site Investigation (SI) conducted by Parsons Engineering Science, Inc. (Parsons ES) [formerly Engineering-Science, Inc. (ES)] at the Nebraska Air National Guard Base, located at Lincoln Municipal Airport in Lancaster County in southeastern Nebraska, approximately 3 miles northwest of the City of Lincoln. The SI was conducted in June, 1989 as part of the Installation Restoration Program. The SI is a mechanism for confirming the presence or absence of environmental contaminants through a limited field sampling program.

The base has been actively operated since 1942 for the servicing of various types of military aircraft, and operations have involved the use and disposal of hazardous materials and wastes. Six sites determined to have the potential for contamination were investigated. History and the SI results are summarized for each of the six sites in the following paragraphs.

Site 1 - Fuel Farm, POL Storage Area

Site 1, located in the southeast quadrant of the base, was used for storage of aviation gasoline (AVGAS) and JP-4 fuel. Fuel losses due to leaks or spills have been estimated at more than 10,000 gallons. Fuel recovery operations from 1983 through 1986 recaptured approximately 250 to 300 gallons of primarily JP-4 fuel. Recovery operations were discontinued in 1987 because fuel recovery was minimal.

During this SI, measurable product was found in two monitoring wells, and nitrate, selenium, benzene, ethyl benzene, toluene, and xylenes were detected in ground water. The areal extent of dissolved petroleum contaminants in the ground water exceeded that of the free product. Petroleum hydrocarbon concentrations in ground water appear to have generally decreased since 1983.

Benzene, nitrate, and selenium were shown to exceed their respective human health criteria, and nitrate exceeded its ecological criteria. Therefore, Site 1 poses a potential health risk, and additional investigations are recommended to further characterize this site.

Site 2 - West End of Old Oak Creek

Oak Creek was rerouted off the base south of a new runway in 1952 and 1953. The abandoned onsite portion of the channel, known as Old Oak Creek, contains a semi-stagnant body of water into which industrial wastes from base operations may have been released. Potential contaminants include motor oils, JP-4 fuel, heavy metals, hydraulic oils, various solvents, and paint remover.

Surface water samples were collected from the Old Oak Creek channel and from the municipal airport outfall. Low concentrations of petroleum hydrocarbons were detected in two surface water samples downstream from Site 1; none were detected in the creek upstream from Site 1. Arsenic and selenium were detected in surface water samples at levels slightly higher than those detected in ground water from upgradient wells.

Sediment samples collected from the Old Oak Creek channel contained toluene, phthalates, polynuclear aromatic hydrocarbons (PNAs), relatively high concentrations of petroleum hydrocarbons, and higher levels of anions and metals than those detected in surface water samples. Samples from a background ground water well installed at the upstream end of Old Oak Creek contained low levels of petroleum hydrocarbons, indicating that this well is not completely upgradient of contamination sources.

Comparison of sample analysis results to applicable or relevant and appropriate requirements (ARARs) and other preliminary risk evaluation criteria revealed that nitrates in ground water and arsenic in sediments at Site 2 exceeded their respective human health criteria. Nitrate concentrations in ground water exceeded ecological criteria, and total cadmium and lead concentrations in sediment exceeded the phytotoxic criteria for plants. The phytotoxic criterion for lead is based on the soluble fraction. Detected lead concentrations did not exceed phytotoxicity guidelines for total lead in soils. Due to the proximity of Site 2 to Site 1, contaminant concentrations at Site 2 adjacent to and downstream of Site 1 could increase and may pose potential health or environmental concerns. Therefore, no further action is recommended for the upstream portions of Site 2, and the lower portions are proposed for inclusion in Site 1.

Site 3 - Former Tank Cleaning/Hazardous Waste Storage Area

Site 3, located south of Site 1 and adjacent to Site 4, was used during the 1970's to clean tank trucks and mobile storage tanks. The tank-cleaning operations were discontinued in 1982, and the volume of waste released is unknown. One recorded release involved a 4,000-gallon spill of JP-4. Thinners, solvents, and acids were also stored at Site 3 until the 1970's.

Petroleum hydrocarbons, arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were detected in soils at Site 3. Metals concentrations were within reported background ranges. In ground water, petroleum hydrocarbons were not detected and levels of anions and metals were similar to those detected in upgradient wells.

Arsenic in soils exceeded the human health criterion, and lead and fluoride in soils exceeded plant phytotoxic levels. The phytotoxic level for lead is based on the soluble fraction. Lead concentrations did not exceed phytotoxicity guidelines for total lead in soils. The potential for adverse health or environmental effects at Site 3 is low, and therefore no further action is recommended.

Site 4 - Access Road, Dust Control Area

Site 4, located along the east end of the Old Oak Creek channel, is known as South Rock Road. Waste oils, thinners, and diesel fuel were sprayed on the road for dust control from 1958 to 1972.

Black discoloration and/or oil odors were noted throughout the full depths of two soil borings, and in the top 3 feet of a third boring. Total petroleum hydrocarbons were detected, with the highest concentrations generally occurring in the 0- to 1-foot interval. The highest concentrations of all analyzed metals detected at the facility except for silver were found in the 0- to 1-foot depth at Site 4, and decreased considerably at the 4- to 5-foot depth.

Arsenic in soils exceeded its human health criteria, and fluoride and lead exceeded plant phytotoxic levels. The phytotoxic level for lead is based on the soluble fraction. Lead concentrations did not exceed phytotoxicity guidelines for total lead in soils. Risks to human health and environmental receptors at this site are low, and no further action is recommended for Site 4.

Site 5 - Army National Guard Oil Storage Area

Site 5 is located west of Center Avenue and adjacent to Building 640. Waste oils are stored in an aboveground 400-gallon tank, which is emptied periodically by a local contractor. Spills and tank overflows have occurred, and oil contamination has been observed near the tank.

Soils at Site 5 contained varying amounts of dark gray discoloration, and fuel odors were noted. Petroleum hydrocarbons were present in soil samples, but were not detected in ground water. Metals concentrations in soils were less than or similar to mean background values, while ground water beneath the site contained levels of metals and anions generally similar to levels of these constituents detected in upgradient wells.

Arsenic in soils exceeded its human health criterion, and fluoride in soils exceeded its plant phytotoxic level. According to available data, both elements are naturally occurring. Therefore, no further action is recommended.

Site 6 - Hydraulic Pressure Check Unit Storage Area

Site 6 is located adjacent to Building 632. Hydraulic pressure-check units are stored on a concrete lot and are known to have often leaked hydraulic fluid. Vegetation adjacent to an outfall from the lot was stressed.

Petroleum hydrocarbons were detected in soils; however, the levels of metals detected in soils were comparable to reported average background values. A ground water sample analyzed for volatile and semivolatile organics, total petroleum hydrocarbons, common anions, and metals contained only arsenic and barium at concentrations similar to those detected in upgradient wells.

In a comparison to ARARs and other criteria, arsenic in soils was found to exceed its human health criterion. Available data indicate that arsenic is naturally occurring, and no further action is recommended for this site.

Conclusions and Recommendations

Based on information collected during the SI, no further action is needed at Sites 3, 4, 5, and 6, or the portions of Site 2 upstream of Site 1. Portions of Site 2 that are downstream of Site 1 should be included in Site 1, and additional information should be obtained for Site 1 through an extended SI. The objectives of the extended SI should be to obtain data from existing and proposed additional monitoring and recovery wells and from soil borings to better define the nature and lateral and vertical extent of ground water and soil contamination. Also, additional soil samples from an uncontaminated area should be collected to establish background levels of anions and metals. Surface water monitoring in the downstream portion of Old Oak Creek should be continued.

The shallow ground water at Site 1 has little or no potential for use as a drinking water supply. In such cases, cleanup of readily-removable contaminants (i.e., free product) and monitoring are required. It may also be necessary to set cleanup levels which protect streams from contaminated ground water discharge that would violate surface water standards. The recommended activities are designed to facilitate achievement of these remedial action objectives.

SECTION 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

The Air National Guard (ANG) responds to releases or potential releases of hazardous substances under Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Section 104 establishes the authority of the President of the United States (U.S.) to respond to such releases and mandates that any such response must be consistent with the National Contingency Plan (NCP) as outlined in Title 40 of the Code of Federal Regulations (CFR), Part 300. In Section 120 of the Superfund Amendments and Reauthorization Act (SARA), Congress requires federal facilities to respond to hazardous substance releases in the same manner and to the same extent as nongovernmental entities. Section 120(a)(4) of SARA requires federal facilities which are not on the National Priorities List (NPL) to comply with state laws concerning remedial and removal actions, provided these laws are not discriminatory towards the federal facility.

To assure compliance with CERCLA regulation, the U.S. Department of Defense (DOD) developed the Installation Restoration Program (IRP). The IRP is the basis for response actions at ANG installations under the provisions of CERCLA. Current DOD policy is to implement activities following the recent guidelines established under SARA. The IRP now consists of six primary efforts, referred to as Preliminary Assessment (PA), Site Investigation (SI), Remedial Investigation/Feasibility Study (RI/FS), Remedial Design (RD), and Remedial Action (RA).

The report presents results of the SI conducted for six sites at the Nebraska Air National Guard Base (herein referred to as Nebraska ANGB) located within the Lincoln Municipal Airport. The U.S. Department of Energy (DOE) has been designated to provide technical assistance to the National Guard Bureau (NGB) for the clean-up of these sites. Martin Marietta Energy Systems (Energy Systems) has been assigned responsibility for managing the Hazardous Waste Remedial Actions Program (HAZWRAP) under Interagency Agreement No. 1489-1489-A1 with DOE. This report has been prepared by Parsons Engineering Science, Inc. [formerly Engineering-Science, Inc. (ES)] under contract for HAZWRAP under General Order No. 18B-97387C, Task Order Y-03.

The SI serves as a mechanism for confirming the presence or absence of environmental impacts through a limited screening program of field sampling. The SI is designed to be comprehensive enough to establish the presence or absence of contamination, but not sufficient to fully characterize the site. The SI developed

sufficient information for each of the six sites at Nebraska ANGB to support either preparing a document justifying no further action, or obtaining additional information through a remedial investigation.

This report is organized into two volumes. Volume 1 contains the text and Appendix A. Volume 2 contains Appendices B through E. The text is organized into six sections including this introduction as Section 1. Section 2 describes the environmental setting of the base, and Section 3 describes the investigative program conducted at each of the six sites. Investigative findings are presented in Section 4 and Section 5 presents the preliminary risk evaluation. Recommendations and conclusions are presented for each site in Section 6. Appendix A includes a glossary, list of acronyms, and a list of units of measurement used. Appendix B includes well data and boring logs, and Appendix C includes survey data. Appendix D includes quality control data, and Appendix E includes all analytical results. In addition, preceding the text are a table of contents and an executive summary, and a reference section follows the text.

1.2 PROGRAM SCHEDULE

The IRP program at Nebraska ANGB was initiated with the PA, which was performed in 1986 and 1987. The work plans for the SI were approved in May of 1989. Field work began on 19 June 1989 and was completed on 26 June 1989.

1.3 BACKGROUND INFORMATION

Nebraska ANGB is located at Lincoln Municipal Airport in Lancaster County in southeastern Nebraska, approximately 3 miles northwest of the City of Lincoln (Figure 1.1). The Nebraska ANGB encompasses 171 acres of generally level terrain with poorly-developed drainage. The base has been actively operated since 1942. Various types of military aircraft have been based and serviced here, and base operations have involved the use and disposal of materials and wastes which are classified as hazardous.

The Hazardous Materials Technical Center conducted a PA and identified nine potentially hazardous sites in 1986 and 1987 (Hazardous Materials Technical Center, 1987). The investigative methods used were site visits and interviews with Nebraska ANGB personnel. As a result, six of the nine sites were determined to have the potential for contamination (Figure 1.2), and three were determined to not require a Hazard Assessment Score (HAS) or further investigation. The three sites determined to not require a HAS are: Site 7 - Army National Guard Fence, North of Building 640; Site 8 - Former Hazardous Waste Storage Area; and Site 9 - F-86 Crash. At Site 7 the only evidence of environmental stress was attributed to sterilant used twice a year to control weeds along the fence. At Site 8 there were no reports of significant waste spillage and no signs of vegetative stress. While a spill did occur at Site 9, it was estimated to be minimal and there were no signs of vegetative stress. The six sites having the potential for contamination are listed below:

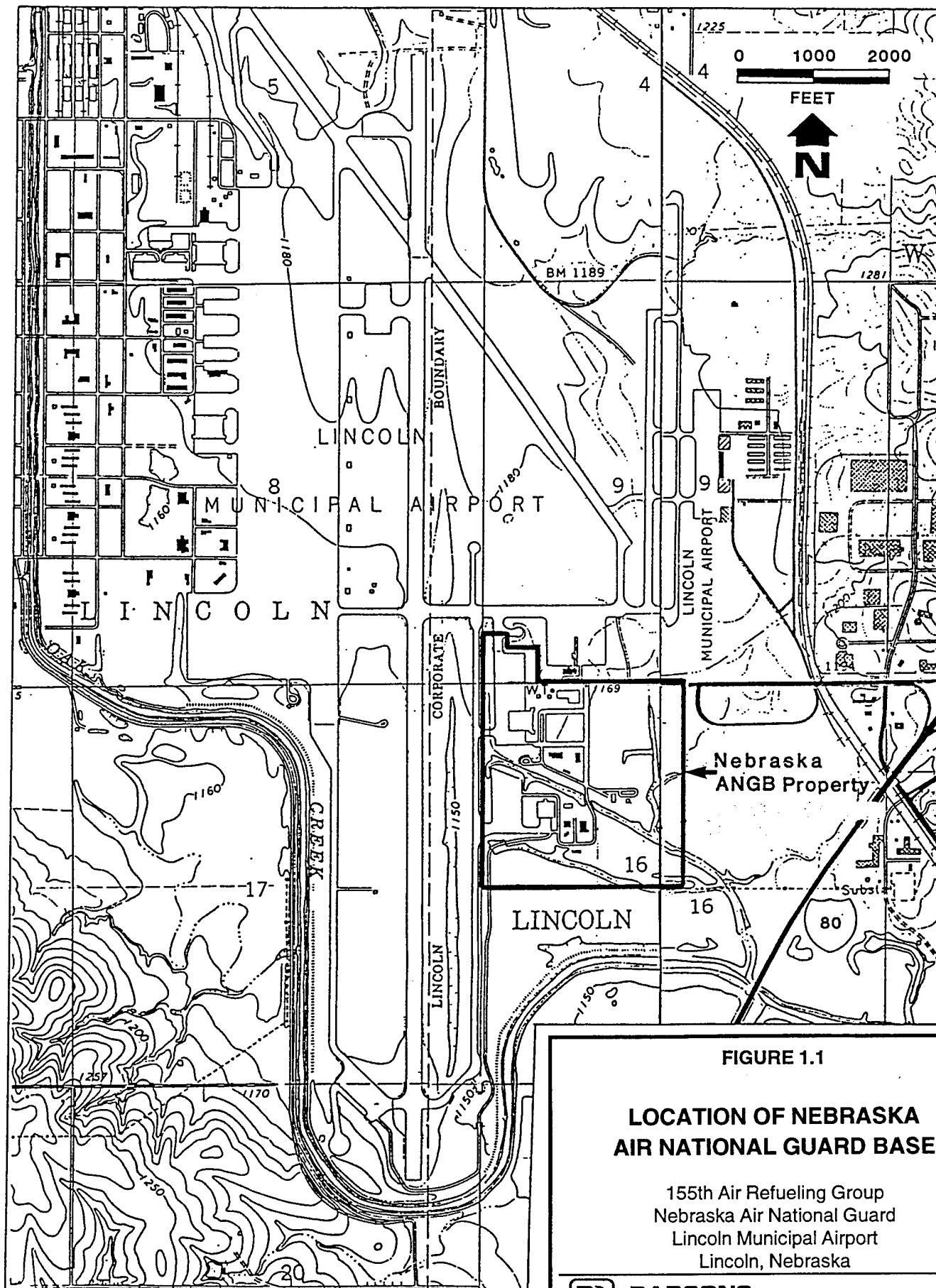
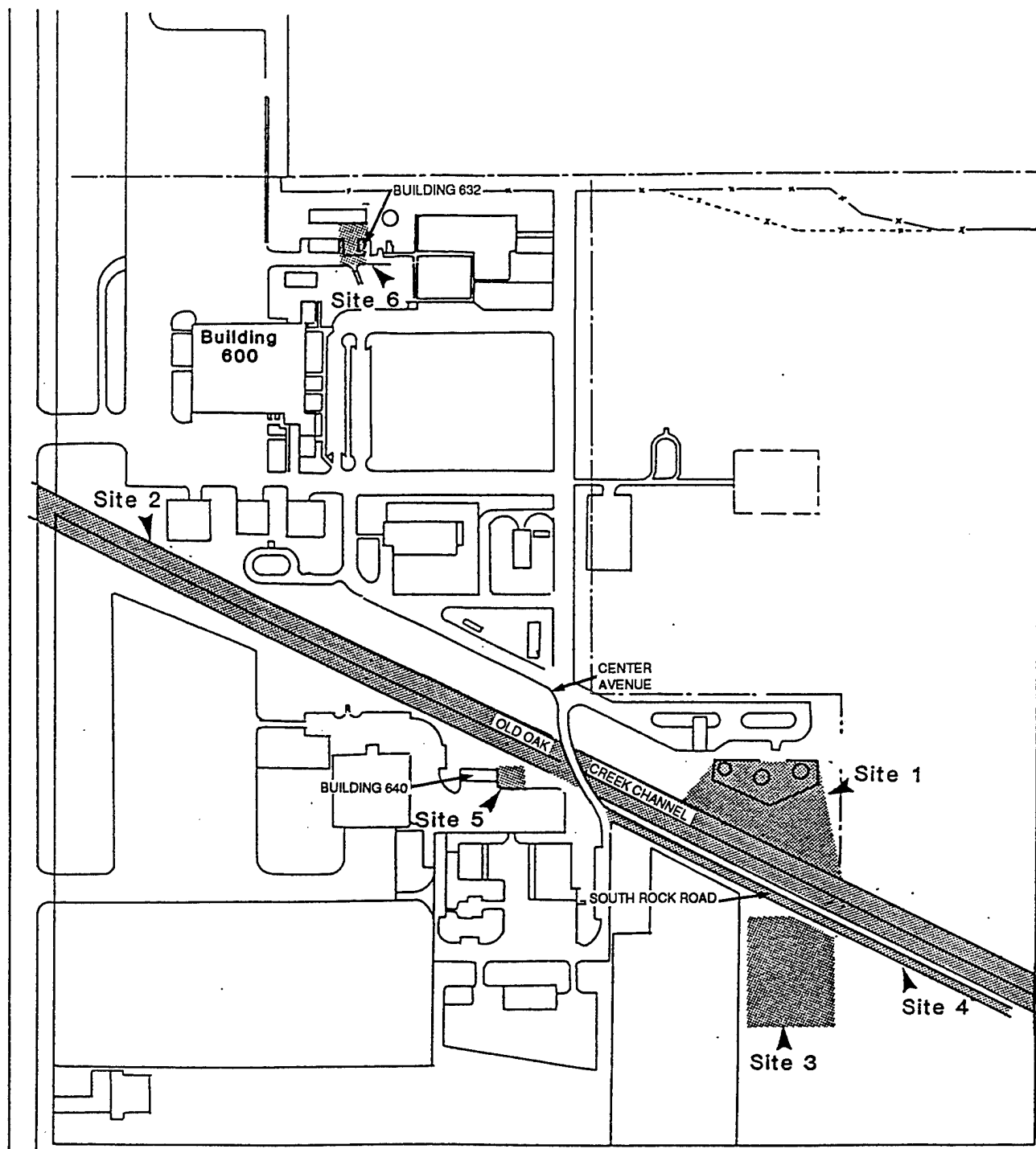


FIGURE 1.1

LOCATION OF NEBRASKA AIR NATIONAL GUARD BASE

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska

**PARSONS
ENGINEERING SCIENCE, INC.**
Denver, Colorado



LEGEND

 STUDY SITE



0 100 200
Feet

FIGURE 1.2

STUDY SITE LOCATIONS

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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Source: Base Records

- Site 1 - Petroleum, Oils, and Lubricants (POL) Storage Area;
- Site 2 - Old Oak Creek Channel;
- Site 3 - Former Tank-Cleaning Area;
- Site 4 - South Rock Road;
- Site 5 - Army National Guard Oil Storage Area; and
- Site 6 - Hydraulic Fluid Spill Area.

Initial investigations of these sites are included in the PA while further investigations of these sites are the subject of this SI. A background description of the six sites is provided in the following paragraphs.

1.3.1 Site 1-POL Storage Area

Site 1 is located in the southeast quadrant of the base (Figure 1.2). During the 1940's and 1950's, when this facility was operated as a navy base, aviation gasoline (AVGAS) was stored in underground storage tanks at this site. By 1959-60, AVGAS storage was replaced with JP-4 fuel storage. During the period from 1956 to 1966, fuel losses due to leaks or spills have been estimated at 10,000 gallons. In 1984, there was a large jet fuel leak which travelled through the POL Storage Area and seeped into Old Oak Creek (Figure 1.2). Most of the leaked fuel was recovered using absorbent materials.

In addition to major spills, a minor leak was discovered from a pin-size hole in one of the JP-4 fuel storage tanks in 1982. No reliable estimate of fuel losses can be made because it is unclear when the hole developed. Results of analyses of samples taken from 17 test holes drilled around the storage tank by Nebraska Testing Laboratories indicated that the leaked fuel has remained in the immediate vicinity of the storage tanks. Analyses of ground water samples obtained by the State of Nebraska from Nebraska Testing Laboratories' monitoring wells revealed the presence of petroleum hydrocarbon contamination in several wells. Weston (1983) completed a study of the site in March 1983 and recommended corrective action. Six wells were constructed to recover the leaked fuel. The recovery operations occurred each year from spring to fall during 1983 through 1986. Approximately 250 to 300 gallons of fuel were recovered. The recovered fuel was analyzed and found to contain mainly JP-4 and small amounts of AVGAS. Recovery operations were discontinued in 1987. A decision was made on 28 April 1988 to permanently discontinue use of the system because fuel recovery was minimal.

1.3.2 Site 2-Old Oak Creek Channel

During airport runway construction in 1952 and 1953, Oak Creek was rerouted off the base south of the runway. The abandoned portion of the channel, now known as Old Oak Creek and classified as Site 2 (Figure 1.2), is within base boundaries and contains a semi-stagnant body of water. Over the years, industrial wastes from base operations may have been released into this semi-stagnant water channel. During periods of heavy precipitation, water flows out of Old Oak Creek into Oak Creek, which in turn flows into Salt Creek and ultimately into the Platte River.

Approximately half of the aircraft apron area drains directly into Old Oak Creek through a storm sewer system, and the remaining apron area drains into an oil/water separator located at the upstream end of the channel. The oil/water separator, installed in 1954, is mainly intended for emergencies and has been known to overflow into the channel. Potential contaminants include motor oils, JP-4 fuel, heavy metals, hydraulic oils, and various solvents. Releases usually occurred during aircraft maintenance and cleaning activities. The types and quantities of the discharged materials are not known.

The aircraft maintenance hangar, known as Building 600 (Figure 1.2), has also produced various wastes which may have drained into Old Oak Creek. Because there is no oil/water separator at Building 600, any past spills would have been routed into the channel through the storm sewer. The spillage from this potential source may have totaled 60 to 100 gallons per year and contained PD-680 (solvent cleaner), paint remover, and JP-4 fuel. Extensive precautions are currently implemented to prevent most spills from reaching the storm sewer.

1.3.3 Site 3-Former Tank Cleaning Area

Site 3 is located south of Site 1 and adjacent to Site 4 (Figure 1.2). During the 1970's, tank trucks and mobile storage tanks were cleaned at this site. It has been estimated that 20 to 200 gallons of waste material per tank could have been released. The duration of tank-cleaning operations and the volume of waste released are unknown. However, one release was recorded when 4,000 gallons of JP-4 were accidentally discharged at this site. Tank cleaning was discontinued in 1982.

Hazardous wastes including thinners, solvents, and acids were also stored at Site 3. Storage of hazardous wastes began in the 1970's and continued until the Defense Reutilization and Marketing Office (DRMO) began accepting these wastes. Even though there were no reports of major spills of hazardous wastes at this site, toppled drums had been observed over the years.

1.3.4 Site 4-South Rock Road

Site 4 is located along the east end of the Old Oak Creek channel (Figure 1.2) and is known as South Rock Road. Waste oils, thinners, and diesel fuel were sprayed on the road for dust control from 1958 to 1972, especially during dry summer months. Based on the PA, it has been estimated that 350 gallons per year were sprayed for dust control. Base personnel report that no polychlorinated biphenyl (PCB) contaminated oils were used for spraying.

1.3.5 Site 5-Army National Guard Oil Storage Area

Site 5 is located west of Center Avenue and adjacent to Building 640 and the Old Oak Creek channel (Figure 1.2). The surface topography at the site is relatively flat. Waste oils are stored in an aboveground 400-gallon tank, which is emptied periodically by a local contractor. During the years of operation, spills and tank overflows have occurred. Oil contamination was observed when the white crushed rock surrounding the tank was moved under the direction of ANG personnel.

1.3.6 Site 6-Hydraulic Fluid Spill Area

Site 6, located adjacent to Building 632 (Figure 1.2), is used to store hydraulic pressure-check units. The hydraulic units are stored on a concrete lot when not in use, and are known to have often leaked hydraulic fluid from loose fittings. Vegetation adjacent to an outfall from the concrete lot was stressed.

SECTION 2

ENVIRONMENTAL SETTING

2.1 GEOGRAPHIC SETTING

The environmental setting of Nebraska ANGB is presented through discussions of physiography, cultural geography, climate, ecology, surface water, geology, and hydrogeology. These discussions incorporate both regional and site-specific perspectives.

2.1.1 Physiography

Nebraska ANGB is situated in Lancaster County near the eastern edge of the Great Plains physiographic province (Hazardous Materials Technical Center, 1987). The terrain throughout the county varies moderately from gently sloping to strongly sloping, with a gradual upward slope to the west. The highest elevation (1,520 feet) is found in both the extreme northwestern and southwestern parts of the county; the lowest elevation (1,080 feet) occurs in the northeastern section where Salt Creek leaves the county (Soil Conservation Service, 1980).

The three main physiographic areas found in Lancaster County are uplands, stream terraces, and bottom lands (Soil Conservation Service, 1980). The base is situated in broad bottom lands (i.e., flood plain) adjacent to Oak Creek at an elevation of 1,160 feet. The area in the immediate vicinity of the base/airport complex is relatively flat. However, elevations rise to approximately 1,300 feet in upland areas west, southwest, and northeast of the base.

2.1.2 Cultural Geography

The primary population center near the base is the City of Lincoln which has a population of 189,620. A residential area northeast of the airport known as the Highlands houses another 15,000 to 18,000 individuals. Small towns such as Malcolm and Emerald, which are respectively northwest and southwest of the base, support populations of less than 500 (Griffin, 1989).

Land uses in the vicinity of the base include industrial, commercial, transportation, residential, agricultural, and recreational activities (Griffin, 1989; Nebraska Department of Roads, 1987).

Large residential areas exist both to the west (Arnold Heights) and northeast (Highlands) of the base/airport complex, as well as in Lincoln to the east and southeast. Cultivated lands, used for crops such as milo, are located north and

northwest of the airport, and to the west of Arnold Heights. Commercial/industrial activities such as the Air Park West development and the Burlington Northern railroad yards are located to the west and south of the airport, respectively. Recreational developments offering primarily picnicking and fishing opportunities are managed by the Lincoln Parks and Recreation Department at a number of lakes within several miles of the base. These lakes include Bowling Lake to the northeast and Capitol Beach and Oak Lakes to the southeast. Figure 2.1 depicts these cultural features.

2.2 CLIMATE

The climate in the area is continental with periods of moderate heat in the summer and cold in the winter. The average summer temperature is 76°F. The highest recorded temperature of 107°F occurred on August 2, 1964. The average winter temperature is 27°F. The lowest temperature on record at Lincoln is -18°F occurring on January 29, 1966.

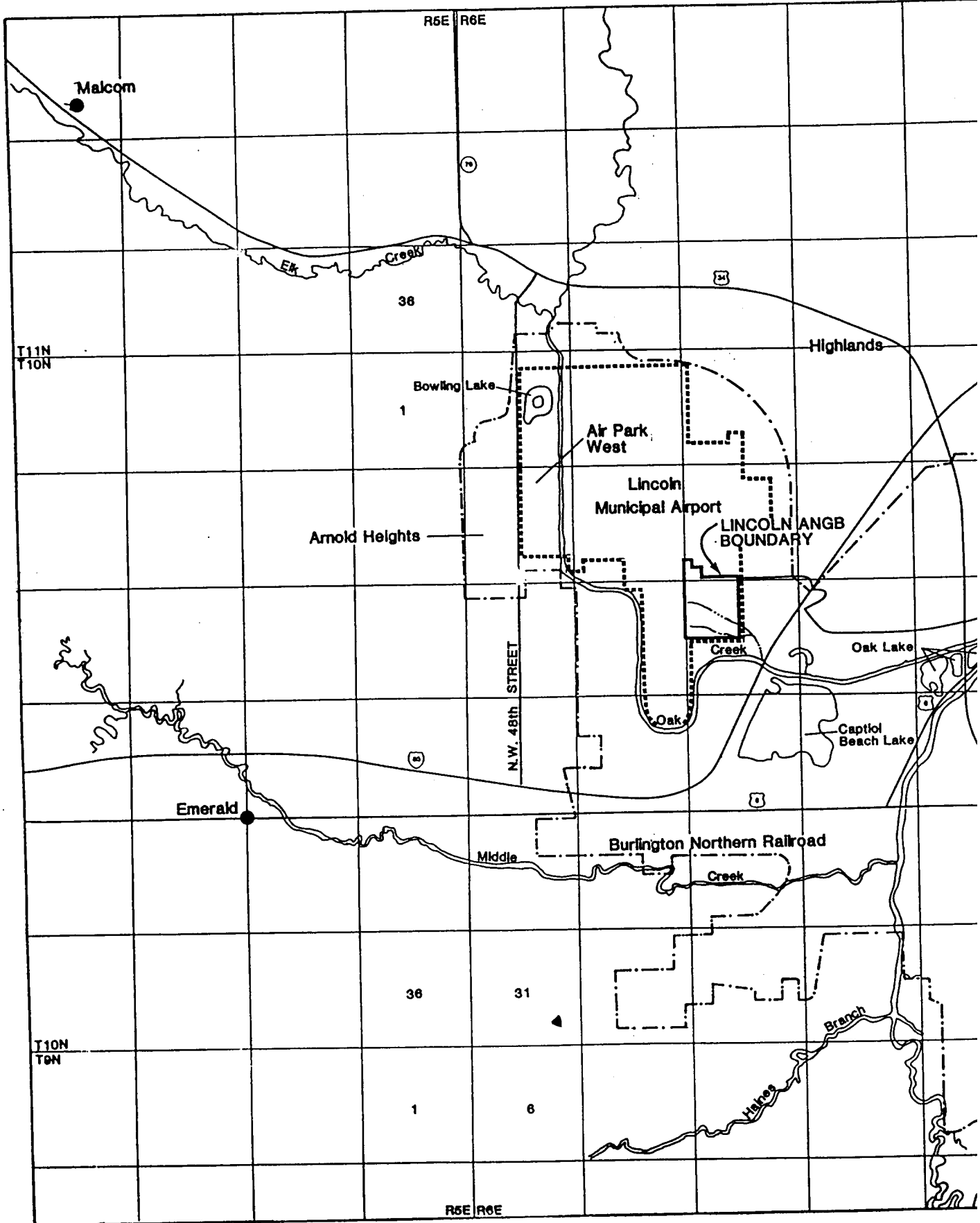
The average annual precipitation is 27.77 inches, with 70 percent of the yearly total occurring during the April through September growing season. Most of the precipitation occurs either because of upslope instability in moist easterly winds, or as thunderstorms with associated high wind. Thunderstorms occur on about 50 days each year, primarily in summer. The average annual snowfall is 28 inches and the greatest snow depth recorded is 21 inches. The upward sloping terrace to the west helps to produce a chinook effect in the winter with associated rapid rises in temperature and shifts of the wind to the west.

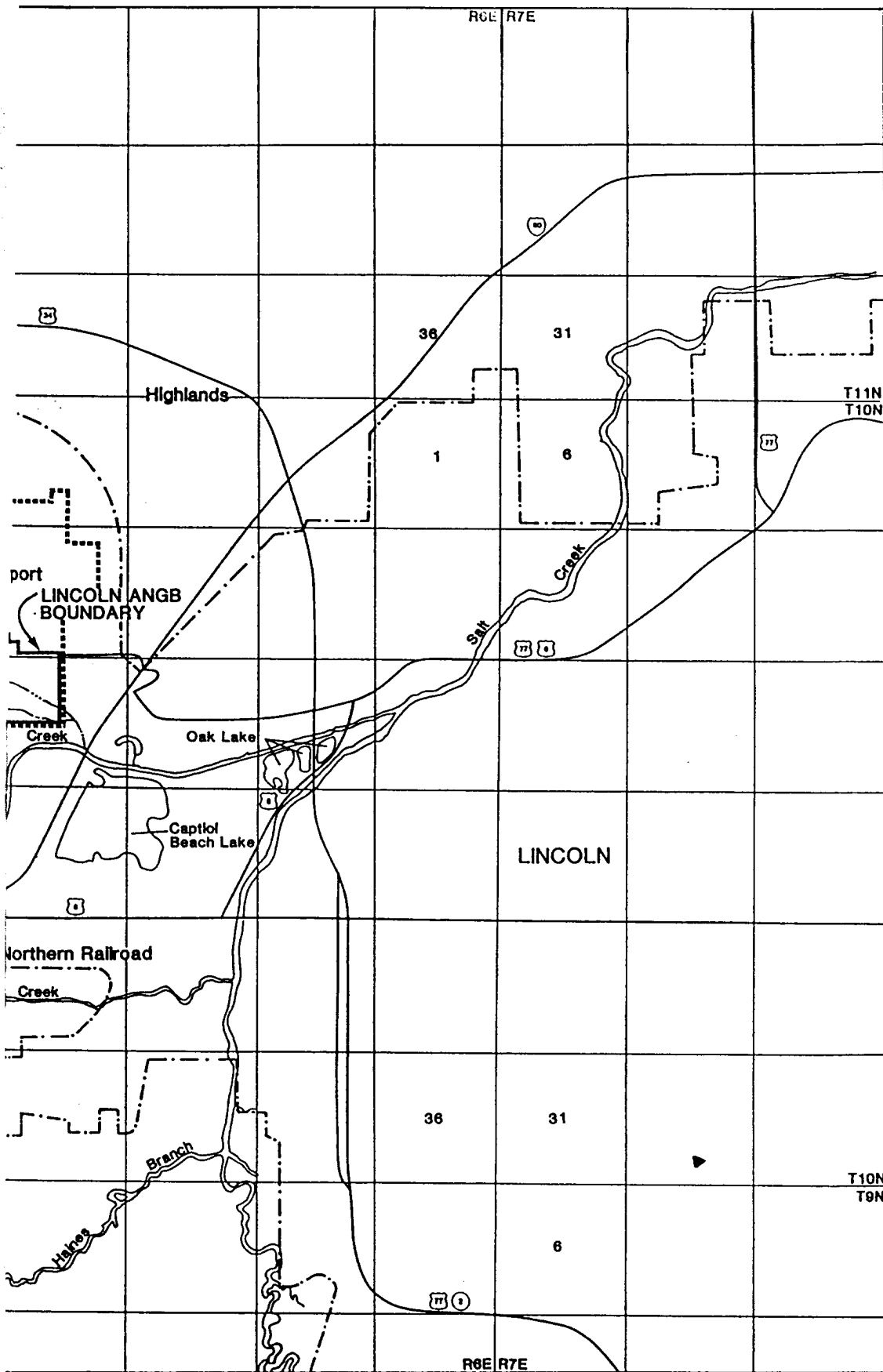
2.3 ECOLOGY

2.3.1 Regional Ecology

Habitat types in the vicinity of Nebraska ANGB include cropland, tall grass prairie, riparian woodland, wetlands and aquatic habitat. The majority of the area surrounding the base is a former tallgrass prairie habitat type. However, crop production and urbanization have replaced most of the native vegetation in the project vicinity. Nonetheless, there are remnant pockets of native tall grass prairie habitat up to 100 acres in size interspersed with cropland and pasture. Wildlife common to tall grass prairies includes mice, voles, cottontail rabbits, badgers, foxes, coyotes, deer, pheasant, bobwhite quail, meadowlarks, field sparrows, owls, redtailed hawks, American kestrel, and Swainson's hawks (Soil Conservation Service 1980; Tunink, 1989). Plant species include big bluestem, little bluestem, switchgrass, indiagrass, and western wheatgrass (Fritz, 1989).

Riparian woodland habitat occurs in scattered strips along perennial and intermittent streams in the project vicinity. Riparian woodlands provide high-quality food, shelter, and nesting habitat for a variety of wildlife including thrushes, woodpeckers, owls, pheasant, squirrels, mice, rabbits, foxes, coyotes, white-tailed deer, mink, opossums, and raccoons. Vegetation in this habitat type includes eastern cottonwood, willows, elm, green ash, burr oak, red-osier dogwood, American plum, brome grass, Kentucky bluegrass, and reed canary grass.





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VICINITY OF
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155th Air F
Nebraska Ai
Lincoln M
Lincoln

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ENGINEER**

Denver

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- APPROXIMATION OF
LINCOLN CORPORATE LIMITS
- APPROXIMATE BOUNDARY OF
LINCOLN MUNICIPAL AIRPORT

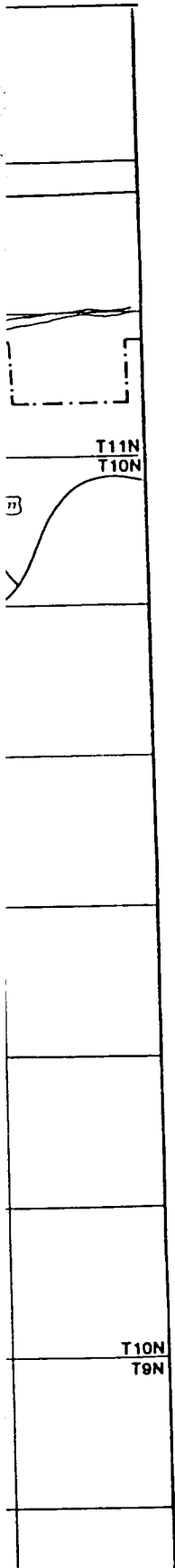


FIGURE 2.1

**MAJOR DEVELOPMENTS IN THE
VICINITY OF NEBRASKA AIR
NATIONAL GUARD BASE**

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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Denver, Colorado

Both freshwater and saltwater wetlands occur in the vicinity of the project site (Figure 2.2). Wildlife occurring in both wetland types include muskrats, mink, raccoon, skunks, rabbits, mice, coyotes, foxes, and a variety of nongame birds. The saltwater wetland receives heavier use by migrating shore birds, wading birds, and waterfowl than the freshwater wetland. Plant species found in the freshwater wetland include cattail, bulrush, sedges, rushes, and smartweed.

The areas to the east and west of Capitol Beach Lake, south of the project site, support a salt marsh of approximately 275 acres that is on the Heritage List of rare and unique habitats. Plant species common to this salt marsh include inland saltgrass, seabligh, spearscale, fowl mannagrass, western wheatgrass, and foxtail barley. Three rare plant species of local concern are also known to occur in this salt marsh habitat. These are glasswort, saltmarsh aster, and Texas dropseed. Another rare plant species of local concern, seaside heliotrope, is suspected to occur, but has not been documented.

Permanent aquatic life populations are found in the five perennial streams and three permanent lakes in the project vicinity. Fish are the aquatic life species of primary concern in these water bodies due to fishing pressure. Fish species found in the vicinity of the base include the following: crappie, walleye, channel catfish, common carp, gold eye, bullhead, green sunfish, flathead minnow, red shiner, and sand shiner (Tunink, 1989; Bliss and Schainost, 1973). In addition to the permanent water bodies, there are numerous stock ponds and intermittent streams which either contain no permanent fish populations or whose species composition has not been documented.

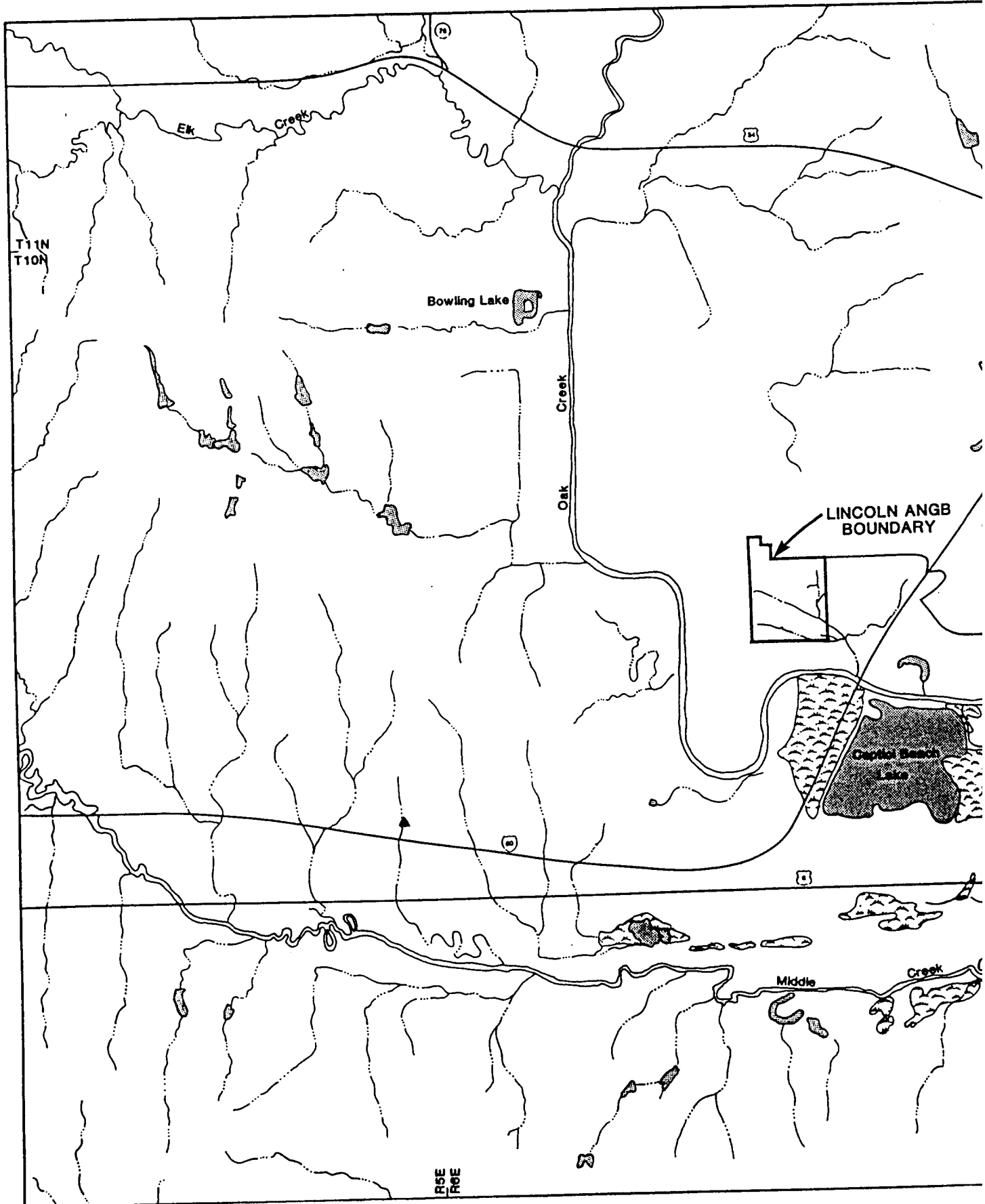
2.3.2 Site Ecology

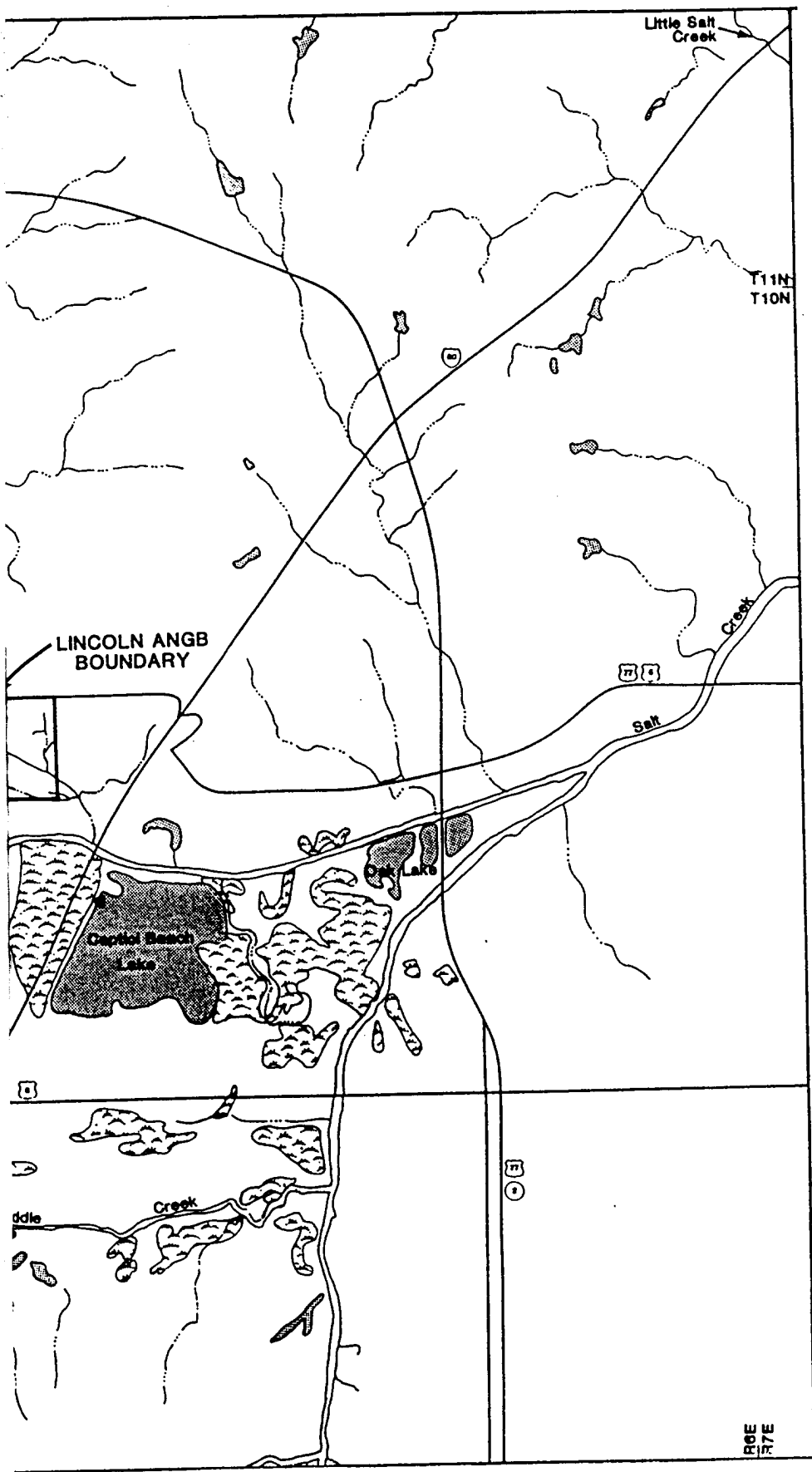
Nebraska ANGB is located on a former tallgrass prairie, but is now approximately 60 percent mowed grass and 40 percent developed. Two intermittent streams flow southeasterly across the site (Figure 2.2), and there is approximately one acre of wetland habitat occurring as narrow bands along these two water courses. Common wildlife species on site include mice, voles, rabbits, skunks, raccoons, foxes, coyotes, retailed hawks, American kestrels, and nongame birds. No threatened, endangered, or special-interest wildlife species are known to occur or rely on the site for critical habitat (Lock, 1989).

2.4 SURFACE WATER

2.4.1 Drainage Basins

Nebraska ANGB is located in the Salt Creek drainage, a tributary to the South Platte River. Five perennial tributary streams of the South Platte River drainage occur within a 3-mile radius of the project site. Oak Creek is a highly channelized stream flowing southward along the west side of Lincoln Municipal Airport for approximately 1.5 miles and then turning east to its confluence with Salt Creek approximately 3 miles east of the project site (Figure 2.2). It flows in a southerly direction for 49.5 linear miles from its headwaters to its confluence with Salt Creek (Lindeman, 1989). Salt Creek flows in a northeasterly direction through the project vicinity from Sawyer Snell Park to its confluence with Oak Creek. Antelope Creek





LEGEND



SALT MARSH



LAKES AND PONDS



INTERMITTENT STREAM



FIGURE 2.2

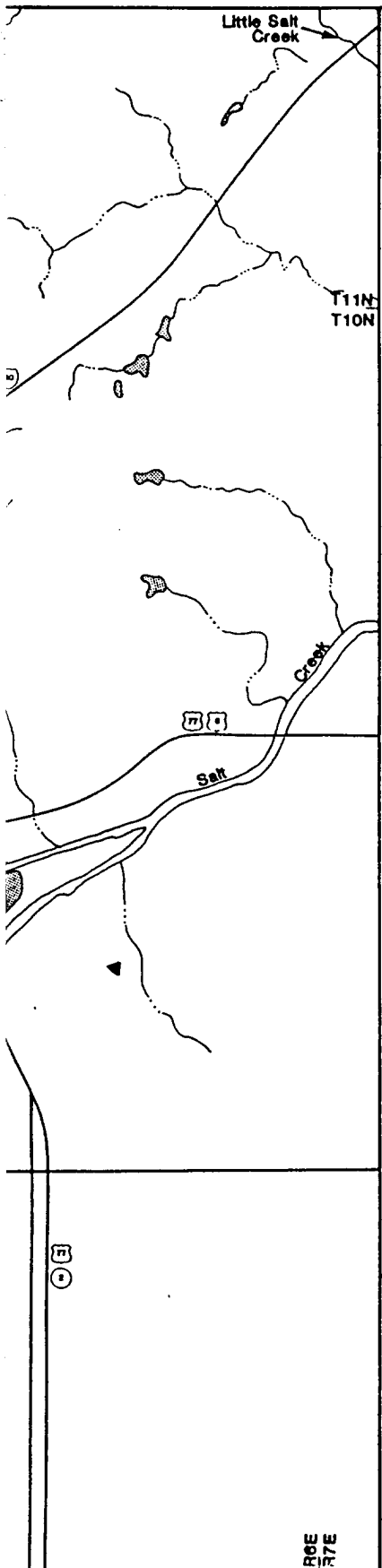
ECOLOGICAL FEATURES

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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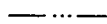
LEGEND



SALT MARSH



LAKES AND PONDS



INTERMITTENT STREAMS



FIGURE 2.2

ECOLOGICAL FEATURES

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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Denver, Colorado

flows north to Salt Creek approximately 0.25 miles south of its confluence with Oak Creek; Middle Creek flows east along the Burlington Northern right-of-way to Salt Creek, approximately 2.5 miles southeast of the project site; and Elk Creek flows southeast to join Oak Creek near Woodlawn, approximately 2.5 miles northwest of the site. The major surface water body occurring on Nebraska ANGB is Old Oak Creek.

During runway construction at the municipal airport, Oak Creek was rerouted off the base south of the runway. The abandoned portion of the channel, now known as Old Oak Creek, is located on ANGB property and contains a semi-stagnant body of water (Site 2 in this study). The area drained by Oak Creek covers approximately 258 square miles and includes several small ponds, lakes, and wetlands (Figure 2.3). Some wetlands occur along the creek.

There are four outfalls to Old Oak Creek. The eastern-most outfall is an open concrete channel receiving drainage from the municipal airport. The western-most outfall is a culvert which drains areas of the municipal airport. Two other outfalls are connected to the storm sewer system of the base.

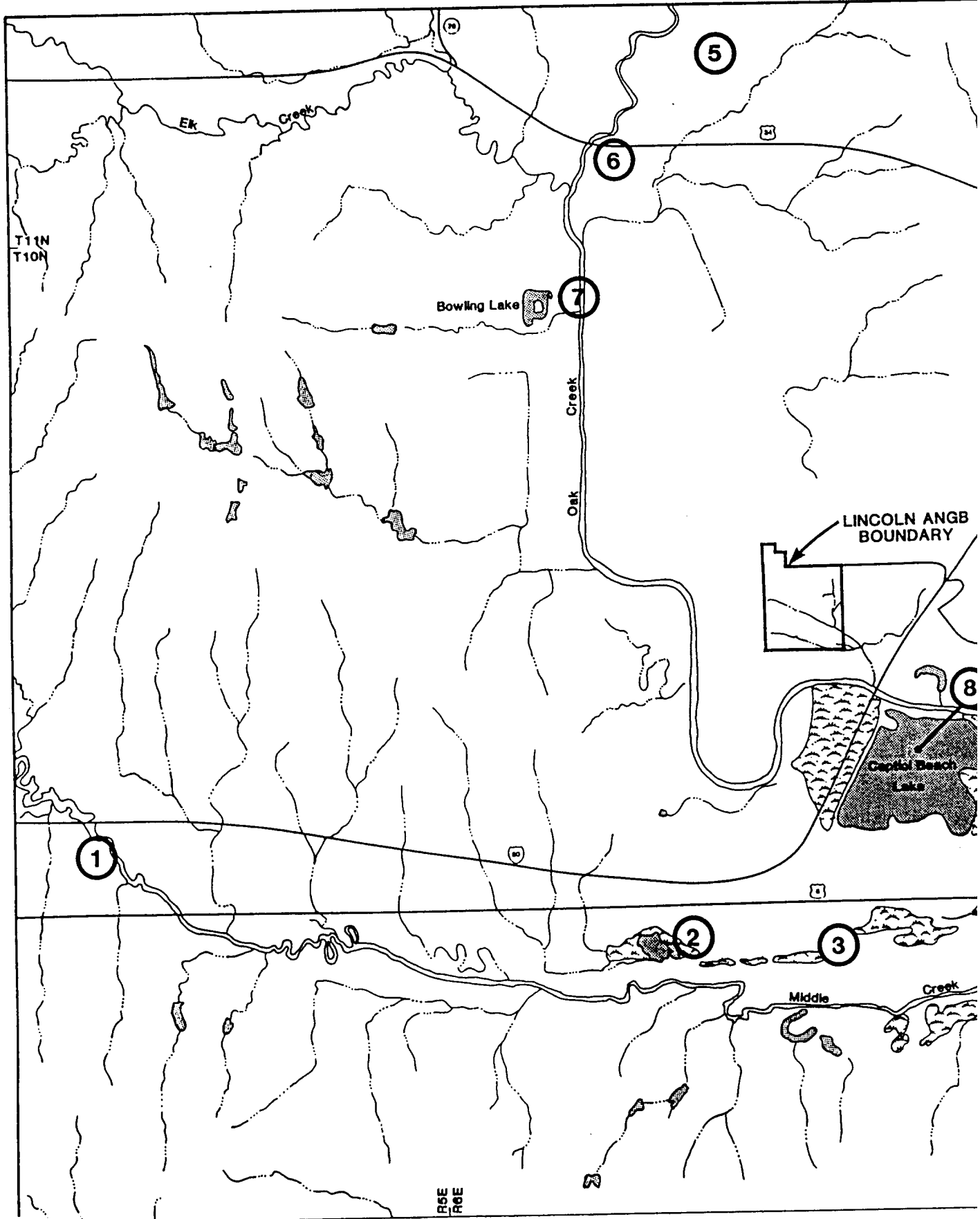
2.4.2 Water Quality

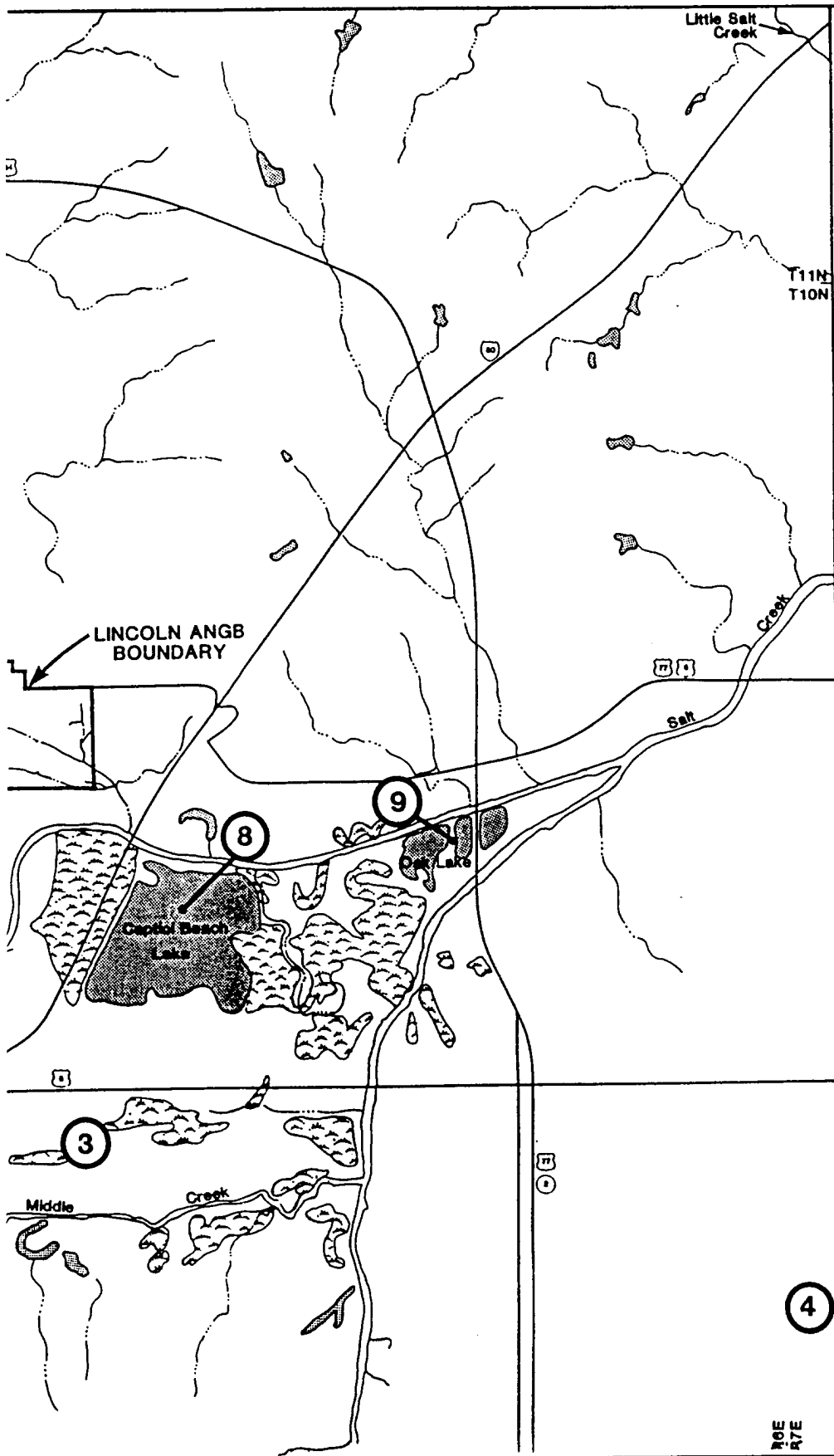
Water quality information is not available for Old Oak Creek and Oak Creek; however, there is no potable surface water in the vicinity of the base. Old Oak Creek and Oak Creek flow into Salt Creek, for which there is water quality information. As a result, Salt Creek water quality is discussed in this section.

As Salt Creek flows through the City of Lincoln, it is subject to stress factors from both point and nonpoint sources of runoff. National Pollutant Discharge Elimination System (NPDES) permits have been issued to each of two wastewater treatment plants, the Theresa Street Wastewater Treatment Plant and the North East Plant, serving the City of Lincoln. During low flow conditions, the Theresa Street Plant discharge contributes approximately 33 percent of Salt Creek's flow while the North East Plant discharge contributes approximately 10 percent of Salt Creek's flow (Miller, 1988).

Historic water quality data for Salt Creek indicate that point sources (wastewater treatment plant effluents) and nonpoint sources (overland runoff) degrade water quality in Salt Creek as it flows through the City of Lincoln. Table 2.1 shows historic water quality data for Salt Creek at a point upstream from the City of Lincoln (Beal Slough) and at a point downstream from the wastewater treatment plant discharges and most of the urban area (North 98th Street). Although Salt Creek has naturally-elevated salt concentrations, water quality parameters associated with salt content increase dramatically as the creek flows through the City of Lincoln. Electrical conductivity (EC) increases by 372 percent, and dissolved sodium and dissolved chloride concentrations increase by 730 and 908 percent, respectively.

The increase in salinity in Salt Creek is noteworthy. However, due to its acute toxicity to aquatic life, the primary parameter of concern in Salt Creek is ammonia. Table 2.1 shows that total nitrogen increases by 219 percent and total ammonia (as nitrogen) increases by 1,445 percent as Salt Creek flows through the City of Lincoln.





LEGEND

1

NUMBERS WITHIN CIRCLES
CORRESPOND TO SURFACE
WATER APPROPRIATION
IN TABLE 2.2

FIGURE 2.3

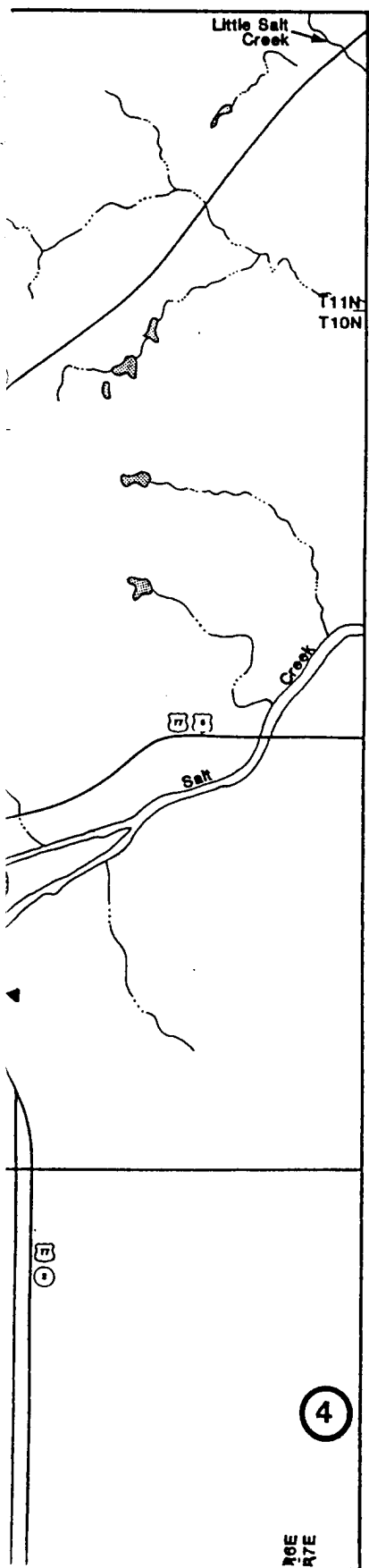
SURFACE WATER APPROPRIATION

155th Air Refueling
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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Denver, Colorado



LEGEND

- ① NUMBERS WITHIN CIRCLES
CORRESPOND TO SURFACE WATER
RIGHTS APPROPRIATIONS DESCRIBED
IN TABLE 2.2



FIGURE 2.3

SURFACE WATER RIGHTS APPROPRIATIONS

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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TABLE 2.1
HISTORIC AVERAGE SALT CREEK WATER QUALITY
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

Parameter ^{a/}	Beal Slough (upstream of the City of Lincoln)	North 98th Street (downstream of the City of Lincoln)
Temperature (°C)	12.2	12.9
Flow (cfs)	60	269
Specific Conductance (μmhos/cm)	1,033	4,878
Dissolved Na (mg/L)	111	921
Dissolved Cl (mg/L)	131	1,321
pH	7.65	7.68
Total Alkalinity (mg/L)	229	283
Total N as N (mg/L)	2.13	6.76
Total N as NO ₃ (mg/L)	10.21	29.73
Total Organic N as N (mg/L)	1.12	1.90
Total Kjeldahl Nitrogen (TKN) as N (mg/L)	1.29	5.24
NO ₃ + NO ₂ as N (mg/L)	0.89	1.55
Total NH ₃ as N (mg/L)	0.20	3.09
Total NH ₃ as NH ₄ (mg/L)	0.15	3.11
Dissolved NH ₃ as N (mg/L)	0.22	5.08
Dissolved NH ₃ as NH ₄ (mg/L)	0.28	6.54

a/ °C = degrees centigrade.
cfs = cubic feet per second.
μmhos/cm = micromhos per centimeter.
mg/L = milligrams per liter.

Source: Miller, 1988.

The increase in total nitrogen and total ammonia concentrations are directly attributable to City of Lincoln effluent discharges.

2.4.3 Surface Water Rights

Surface water appropriations in the vicinity of Nebraska ANGB have been plotted on Figure 2.3 and listed in Table 2.2. Surface water uses include storage, irrigation, and maintenance of fish and wildlife habitat. Surface water appropriations to Oak Lake and Capitol Beach Lake are the only appropriations of Oak Creek downstream from the base.

2.5 GEOLOGY

2.5.1 Regional Geology

Geologic deposits exposed in this region of Nebraska are alluvial, eolian, and glacial deposits of Quaternary age, and sandstone and shale of Cretaceous age. Deep drilling in west Lincoln has encountered alluvial and Pleistocene sands and gravels overlying sandstones and shales of the Lower Cretaceous Dakota Group (Condra and Reed, 1939). Unconsolidated and poorly-consolidated soil and subsoil, Peoria Loess, alluvial sands, gravels, and clays unconformably overlie the Lakota Formation of the Dakota Group. The predominantly sandstone Lakota Formation is the lowermost unit within the Dakota Group. The entire section is about 170 feet thick, although erosion has removed the upper portion in many areas. In some areas, the middle member of the Dakota Group, the Fuson Shale, remains between the Quaternary sediments and the Lakota Formation. This shale is a sandy shale, ranging from varicolored in the upper part to gray in the lower (Condra and Reed, 1959).

The Dakota Group overlies rocks of Permian and Pennsylvanian age. These rocks are principally limestones and shales. Basement rocks are Precambrian igneous and metamorphic complexes, presumably granite and gneiss, although little specific information is known about these units because very few wells have been drilled to that depth. Condra and Reed (1959) report depths for the Precambrian rocks at 1,805 feet below the ground surface east of Lincoln, and about 2,193 feet deep west of Lincoln.

There are no major structural features in Lancaster County, although there are several small anticlines and synclines to the east and southeast. What structure does exist appears to be reflected principally in Pennsylvanian and older rocks. Structural features nearest to Lincoln are the north/south-trending Nehawka-Richfield Arch in Sarpy and Cass Counties, and the northeast-trending Redfield Arch in Cass and Otoe Counties (Burchett and Reed, 1967).

2.5.2 Facility Geology

Nebraska ANGB is underlain by unconsolidated Quaternary deposits overlying the Lakota Formation and Fuson Shale of the Dakota Group. The unconsolidated deposits are characterized by the two lithostratigraphic units which consist of approximately 10 to 22 feet of fine-grained eolian silt and clay deposits (Peoria Loess) overlying a unit of well-sorted fluvial sand and gravel over 15 feet thick. The

TABLE 2.2

SURFACE WATER RIGHTS IN PROJECT VICINITY
LISTED IN DOWNSTREAM ORDER
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

<u>Source,</u> Location, and Appropriator	Carrier	Use ^{a/}	Grant ^{b/}	Date of Priority	Docket/ App. Number
1. <u>Middle Creek</u> Sect. 22, T10N, R5E Lancaster County Harrey Deinea	pump	IR	1.56 cfs	4/21/1977	A14915
2. <u>Middle Creek</u> Sect. 29, T10N, R6E Lancaster County Board of Education Lands & funds Board of Education Lands & funds	pump pump	IR IR	0.03 cfs 0.4 cfs	1/18/1967 1/8/1976	A11021 A14541
3. <u>Middle Creek</u> Sect. 28, T10N, R5E Lancaster County Jose Sanchez et al	pump	IR	0.13 cfs	1/17/1938	A2823
4. <u>Antelope Creek</u> Sect. 31, T10N, R7E Lancaster County Michael D. Coon	pump	IR	0.01 cfs	3/29/1976	A14126

L1-9-11

TABLE 2.2 (Continued)

SURFACE WATER RIGHTS IN PROJECT VICINITY
LISTED IN DOWNSTREAM ORDER
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

<u>Source,</u> Location, and Appropriator	Carrier	Use ^{a/}	Grant ^{b/}	Date of Priority	Docket/ App. Number
5. <u>Oak Creek</u> Sect. 29, T11N, R6E Lancaster County Lillian Carlisle	pump	IR	0.76 cfs	4/3/1969	A11682
6. <u>Oak Creek</u> Sect. 32, T11N, R6E Lancaster County John R. Bennett Trust	pump	IR	5.36 cfs	9/16/1971	A12381
7. <u>Oak Creek</u> Sect. 6, T10N, R6E Lancaster County City of Lincoln	Bowling Lake	ST	176.0 af	4/11/1957	A9442
8. <u>Oak Creek</u> Sect. 15, T10N, R6E Lancaster County Capitol Beach Community Association	Capitol Beach Lake	ST	1430.0 af	6/7/1961	A9944

TABLE 2.2 (Continued)

SURFACE WATER RIGHTS IN PROJECT VICINITY
LISTED IN DOWNSTREAM ORDER
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

Source, Location, and Appropriator	Carrier	Use ^{a/}	Grant ^{b/}	Date of Priority	Docket/ App. Number
9. Oak Creek Sect. 14, T10N, R6E Lancaster County City of Lincoln	Oak Lake	ST	222.89 af	9/13/1982	A16147

^{a/} IR - Irrigation from natural stream.

ST - Storage.

SI - Supplemental irrigation - irrigation from reservoir on lands also covered by Natural Flow Appropriation.

FW - Fish and wildlife.

^{b/} cfs - cubic feet per second.

af - acre-feet.

Source: State of Nebraska, Department of Water Resources (1988).

thickest unconsolidated deposits are located in the paleostream channels eroded into the underlying Lakota Formation and Fuson Shale.

2.6 HYDROGEOLOGY

The science of hydrogeology attempts to explain the nature and distribution of aquifers and aquitards in a geologic system. Characteristics of aquifers and aquitards are controlled by the lithology, stratigraphy, and structure of the geologic deposits and formations. Hydrogeologic characteristics of Nebraska ANGB are discussed here from both a regional and site-specific perspective.

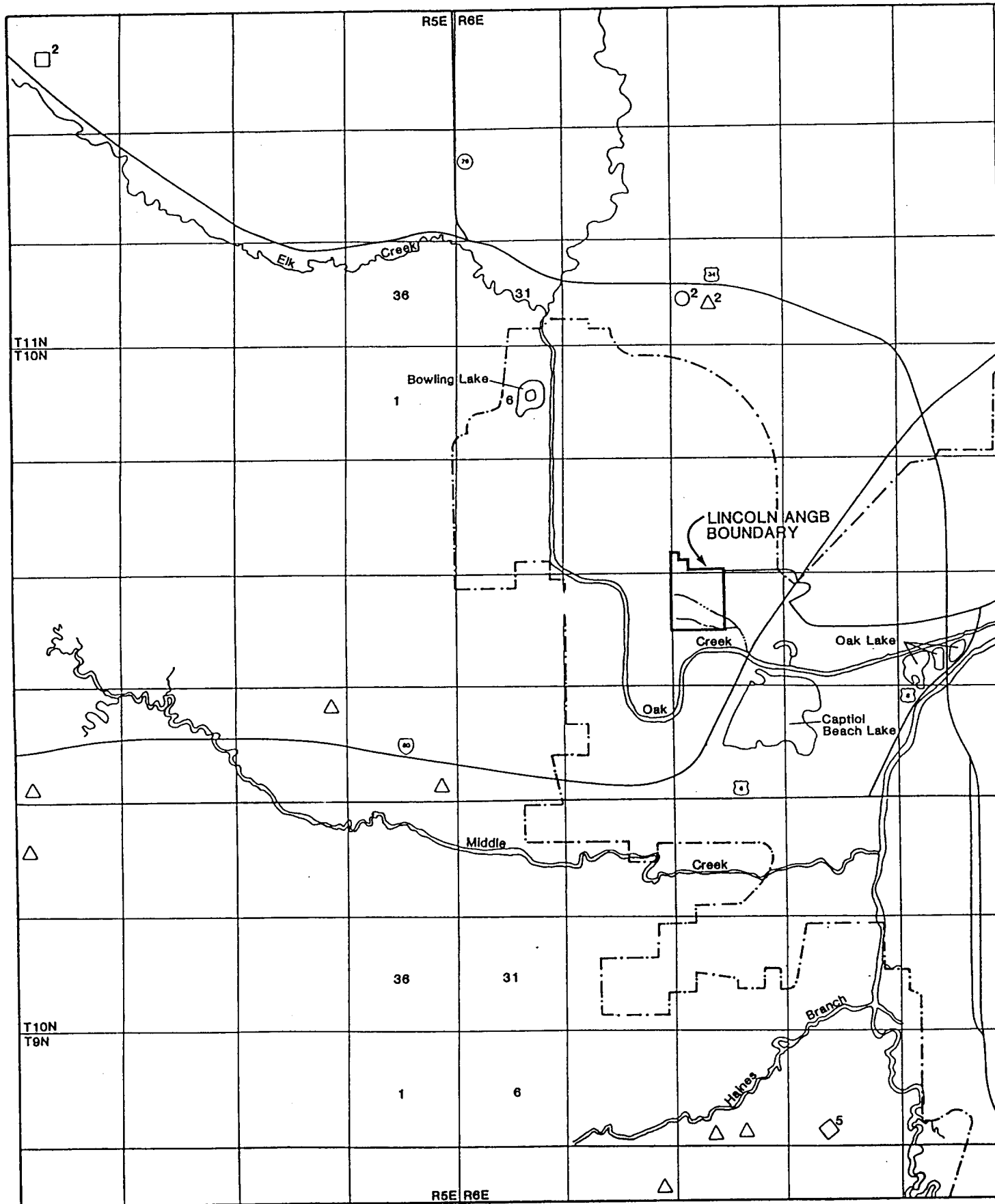
2.6.1 Regional Hydrogeology

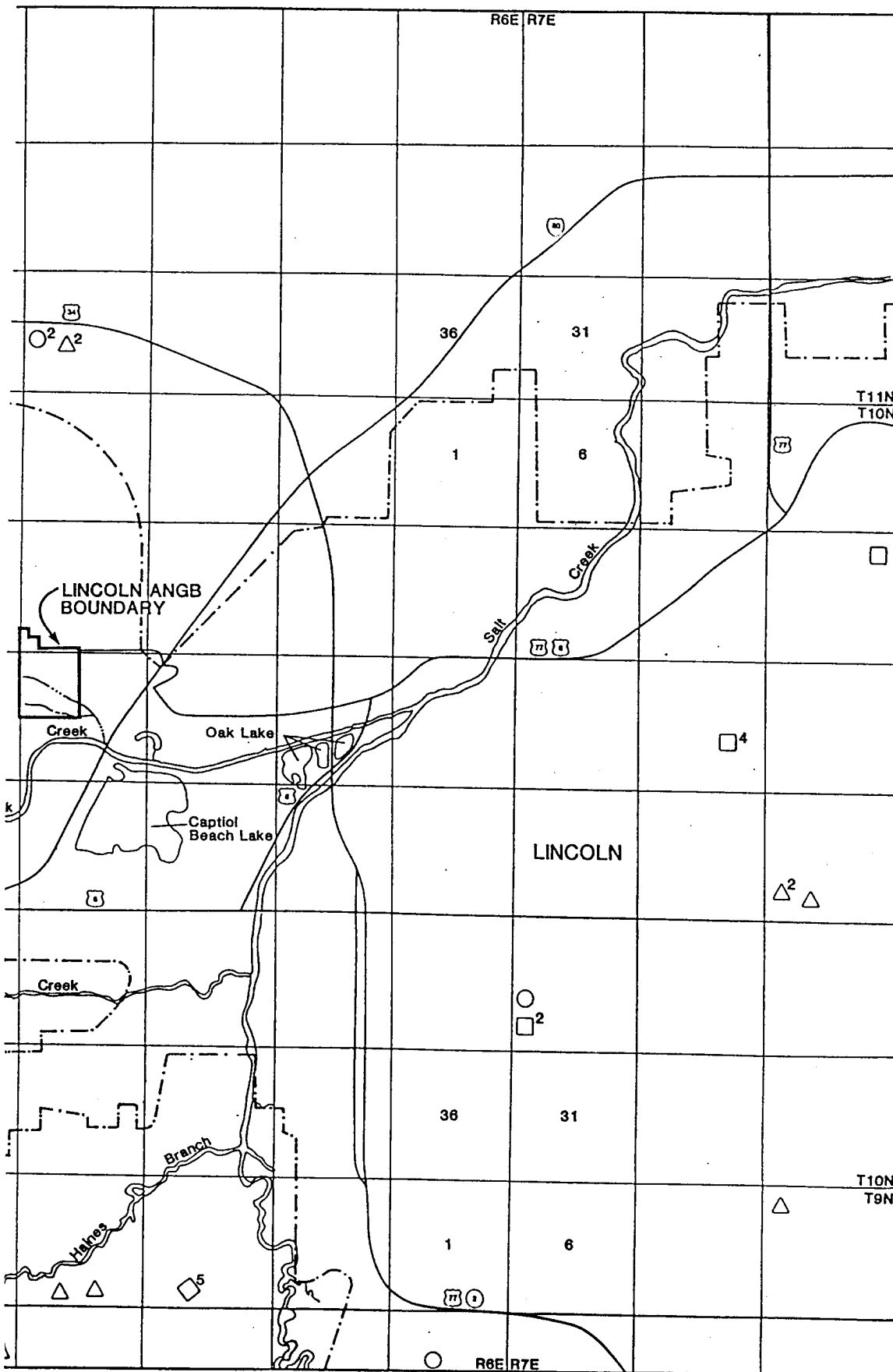
Geology in the region includes three formations of the Dakota Group: an upper sandstone, a middle Fuson Shale, and a lower sandstone. The upper sandstone generally contains water of good quality, while that of the lower sandstone is generally of poor quality. Keech (1962) reported similar characteristics in ground water between the Quaternary deposits and the lower sandstone (Lakota Formation), and hydraulic communication between the Lakota Formation and the Quaternary deposits in the area of the Hallam Nuclear Power Facility southeast of Lincoln. The water was found to be highly mineralized. Where present, the Fuson Shale may provide a low-permeability barrier to vertical infiltration between the Quaternary sediments and the Lakota Formation. The Permian and Pennsylvanian limestones and shales are not sufficiently permeable to serve as ground water aquifers (Keech, 1962).

The principal zones of saturation for the area are the unconsolidated sands and gravels below the regional water table. They may be considered a single aquifer because the units are generally interconnected and all may contribute water to wells. Ground water depth generally ranges from 10 to 40 feet below the ground surface, but the saturated thickness may be influenced by the depth of buried valleys eroded into the underlying bedrock surface. Perched zones of saturation may exist in sands and gravels within or between glacial tills or alluvial clays having relatively lower permeabilities.

Major water production for the area has come from alluvium underlying stream terraces and within the larger stream valley bottom lands and some buried (ancient) alluvial valleys. The sand and gravel alluvium of the lower Salt Creek Valley has produced sufficient water for irrigation. Sand and gravelly-sand within the glacial deposits have produced small quantities of water for domestic and stock-watering purposes. Water quality is generally hard, with sulfate and iron concentrations exceeding recommended limits for some uses. Since 1933, the City of Lincoln has been supplied primarily with water from a well field in the Platte River Basin near Ashland, Nebraska. The water is pumped from a depth of approximately 160 feet (Cotton, 1989), which is considerably deeper than wells sampled at Nebraska ANGB.

Records available from the State of Nebraska, Department of Water Resources indicate that there are four irrigation wells and two commercial wells within a 3-mile radius of the base (Figure 2.4). All of these wells are located in an aquifer





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 - M
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 - ◇ O
 - ⁴ 4
 - A
 - U

NOTE: WELL
NEAR

Source: State
Resou

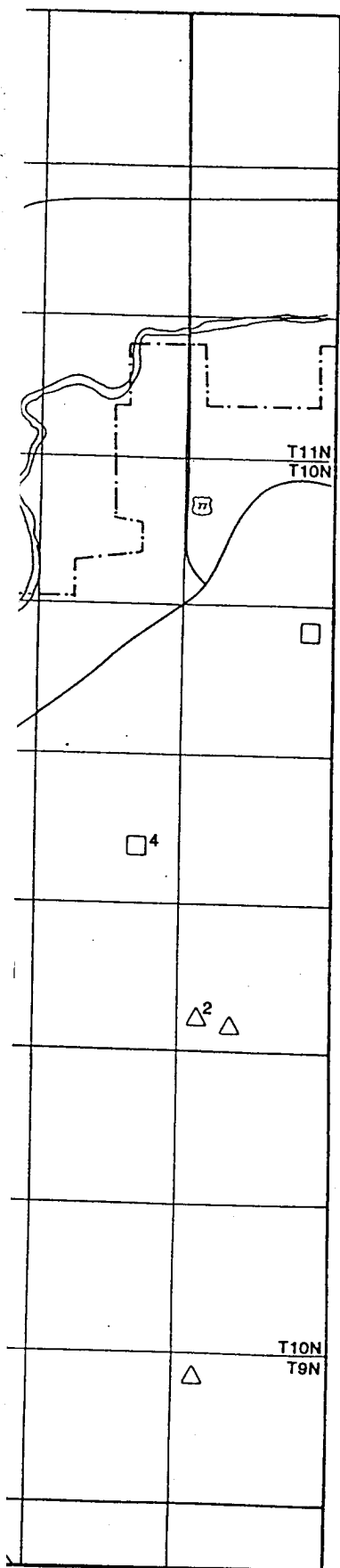
WELL L
VICINITY
NATION

155th
Nebras
Linco
Li



PARSC
ENGINE

De



LEGEND

○ COMMERCIAL

□ MUNICIPAL

△ IRRIGATION

◇ OTHER

□⁴ 4 MUNICIPAL WELLS

--- APPROXIMATION OF
LINCOLN CORPORATE LIMITS

NOTE: WELLS ARE LOCATED TO THE
NEAREST 1/4, 1/4 SECTION



0 1 Mile

Source: State of Nebraska Department of Water
Resources

FIGURE 2.4

WELL LOCATIONS IN THE VICINITY OF NEBRASKA AIR NATIONAL GUARD BASE

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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different than that sampled at Nebraska ANGB. Wells outside the 3-mile radius are also shown on Figure 2.4. These include seven municipal wells for the City of Lincoln. These wells are located between 4.25 and 6.5 miles east and southeast of the base. The municipal wells range in depth from 158 to 169 feet (Cotton, 1989). Well locations, owners, and distance from the base are listed in Table 2.3 for each of the wells plotted on Figure 2.4.

2.6.2 Local Hydrogeology

The depth to ground water in the unconsolidated deposits underlying the base varies from 12 to 40 feet below the ground surface, and ground water flow directions are generally toward the east (Hazardous Materials Technical Center, 1987). The unconsolidated aquifer, which consists of moderately to highly permeable sand, silty sand, and sandy silt of glacial origin, is overlain by relatively low permeability clay and silty clay of alluvial origin. Both the upper, fine-grained and lower, coarse-grained units appear to be fairly continuous across the study area, with the upper unit increasing in thickness towards the southeast. Detailed information about the aquifer's water level, hydraulic gradient, and general quality is discussed in Section 4.0.

TABLE 2.3
GROUND WATER WELLS IN THE VICINITY OF
155TH AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

Location	Use	Owner	Approximate Distance from Base (Miles)
T9N, R6E, Sec. 3, SE¼SW¼ (5 wells)	Other	Lincoln Regional Center	4.5
T9N, R6E, Sec. 4, SE¼SW¼	Irrigation	Adolph Priess	4.5
T9N, R6E, Sec. 8, SE¼NE¼	Irrigation	Adolph Priess	5.0
T9N, R6E, Sec. 4, SW¼SE¼	Irrigation	Robert S. Little	4.5
T9N, R6E, Sec. 12, SE¼NW¼	Commercial	Pegler Sysco Food	5.75
T9N, R7E, Sec. 4, NW¼NW¼	Irrigation	Lloyd Duckett	6.75
T10N, R5E, Sec. 21, SW¼SW¼	Irrigation	Burdette Piening	6.0
T10N, R5E, Sec. 23, NE¼NE¼	Irrigation	Gary Hellerich	3.25
T10N, R5E, Sec. 24, SE¼SE¼	Irrigation	George D. Hellerich	2.5
T10N, R5E, Sec. 28, SW¼NW¼	Irrigation	Adolph Piening	6.0
T10N, R7E, Sec. 9, NE¼NE¼	Municipal	City of Lincoln	6.5
T10N, R7E, Sec. 17, NW¼SE¼ (4 wells)	Municipal	City of Lincoln	5.5
T10N, R7E, Sec. 21, SW¼SW¼ (2 wells)	Irrigation	Bankers Life of Lincoln	5.75
T10N, R7E, Sec. 21, SE¼SW¼	Irrigation	Bankers Life of Lincoln	6.0
T10N, R7E, Sec. 30, NW¼SW¼	Commercial	Paramount Laundry & Cleaners, Inc.	4.5
T10N, R7E, Sec. 30, SW¼SW¼ (2 wells)	Municipal	City of Lincoln	4.5
T11N, R5E, Sec. 21, SE¼NW¼ (2 wells)	Municipal	Village of Malcolm	7.0
T11N, R6E, Sec. 33, NE¼SW¼ (2 wells)	Irrigation	George Cook	2.5
T11N, R6E, Sec. 33, NW¼SW¼ (2 wells)	Commercial	Kawasaki Motors Corporation	2.5

Source: Cotton, 1989.

SECTION 3.0

INVESTIGATIVE PROGRAM

3.1 INTRODUCTION

The purpose of this SI was to confirm or deny the presence of contamination at the previously-described sites. Data gathering and analysis during the SI was conducted in order that:

- An understanding of site hydrogeology could be sufficiently developed to evaluate ground water in the uppermost aquifer.
- The presence of contaminants in ground water, surface water, soils, and sediments could be evaluated.
- Sampling results were representative of actual site conditions.
- Identified sampling and analytical protocol provide data of known quality.
- SI activities have essentially no adverse impact on base activities, human health, or the environment.

The field investigation was designed to serve this purpose but not to fully characterize the site. The field investigation program to meet these objectives included:

- monitoring well installation and ground water sampling and analysis;
- soil sampling and analysis;
- sediment sampling and analysis; and
- surface water sampling and analysis.

Site-specific field investigations were performed in accordance with the SI work plan for all phases of field and analytical programs. Specific objectives for each of the six sites on Nebraska ANGB are described in Table 3.1 together with a description of data gathering activities. Details on the field investigation methods used, as well as a description of the analytical and field quality control programs, are provided in this section.

TABLE 3.1
SITE INVESTIGATION DATA QUALITY OBJECTIVES
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

SITE SI OBJECTIVE	DATA NEEDED	DATA GATHERING ACTIVITIES
1 To confirm or deny the presence of ground water contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth Remedial Investigation (RI).	Ground water levels and water quality samples analyzed for volatile organics, semi-volatile organics, petroleum hydrocarbons, heavy metals, and common anions.	<ul style="list-style-type: none"> Survey elevation of existing wells and measure water levels. Sample, and analyze 6 wells. Install 1 background well, survey elevation, monitor static water level and collect a ground water sample.
2 To confirm or deny the presence of surface water and sediment contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth RI.	Surface water samples and sediment samples analyzed for volatile organics, semi-volatile organics, petroleum hydrocarbons, heavy metals, and common anions.	<ul style="list-style-type: none"> Sample and analyze 5 sediment and surface water samples. Measure surface water flow, establish staff gaging stations, survey staff gaging stations and measure surface water elevations during flow monitoring. Install 1 background well, survey elevation, measure static water level, and collect a ground water sample.
3 To confirm or deny the presence of soil and/or ground water contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth RI.	Soil samples and 1 ground water sample analyzed for volatile organics, semi-volatile organics, petroleum hydrocarbons, heavy metals and common anions.	<ul style="list-style-type: none"> Drill 2 soil borings and collect split spoon samples. Drill 1 soil boring, collect soil samples, convert soil boring to monitoring well, survey elevation, measure static water level, and collect a ground water sample.
4 To confirm or deny the presence of soil contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth RI.	Soil samples analyzed for petroleum hydrocarbons, PCBs, heavy metals, and common anions.	<ul style="list-style-type: none"> Drill 3 soil borings and collect split spoon samples.

TABLE 3.1 (Continued)
 SITE INVESTIGATION DATA QUALITY OBJECTIVES
 155th AIR REFUELING GROUP
 NEBRASKA AIR NATIONAL GUARD
 LINCOLN MUNICIPAL AIRPORT
 LINCOLN, NEBRASKA

SITE SI OBJECTIVE	DATA NEEDED	DATA GATHERING ACTIVITIES
5 To confirm or deny the presence of soil and/or ground water contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth RI.	Soil samples and ground water samples analyzed for volatile organics, semi-volatile organics, petroleum hydrocarbons, heavy metals, and common anions.	. Drill 1 soil boring, collect soil samples, convert soil boring to monitoring well, survey elevation, measure static water level and collect a ground water sample.
6 To confirm or deny the presence of soil and/or ground water contamination, to assess risks associated with confirmed contamination to potential receptors, and to determine the need for a more in depth RI.	Soil samples and ground water samples analyzed for volatile organics, semi-volatile organics, petroleum hydrocarbons, and heavy metals.	. Drill 1 soil boring collect soil samples, convert soil boring to monitoring well, survey elevation, measure static water level and collect a ground water sample.

3.2 FIELD INVESTIGATION METHODS

3.2.1 Drilling, Soil Sampling, and Well Construction Activities

Nine soil borings were drilled at Nebraska ANGB to identify subsurface geologic and hydrogeologic conditions and to assess the presence of contamination through soil and ground water sampling. Four of the borings were converted to monitoring wells. The remaining borings were backfilled with cuttings upon completion of the sampling. Locations of the borings and monitoring wells are shown in Figure 3.1.

3.2.1.1 Drilling Procedures

Five borings (3-BH2, 3-BH3, 4-BH1, 4-BH2, and 4-BH3) were hand-augered at selected locations within Sites 3 and 4 on 20 and 21 June 1989. The borings were advanced using a 4-inch-diameter bucket hand auger to a total depth of 5 feet below ground surface. Decontamination of the auger was performed after each sample collection. These borings were logged and backfilled upon completion of the sample collection.

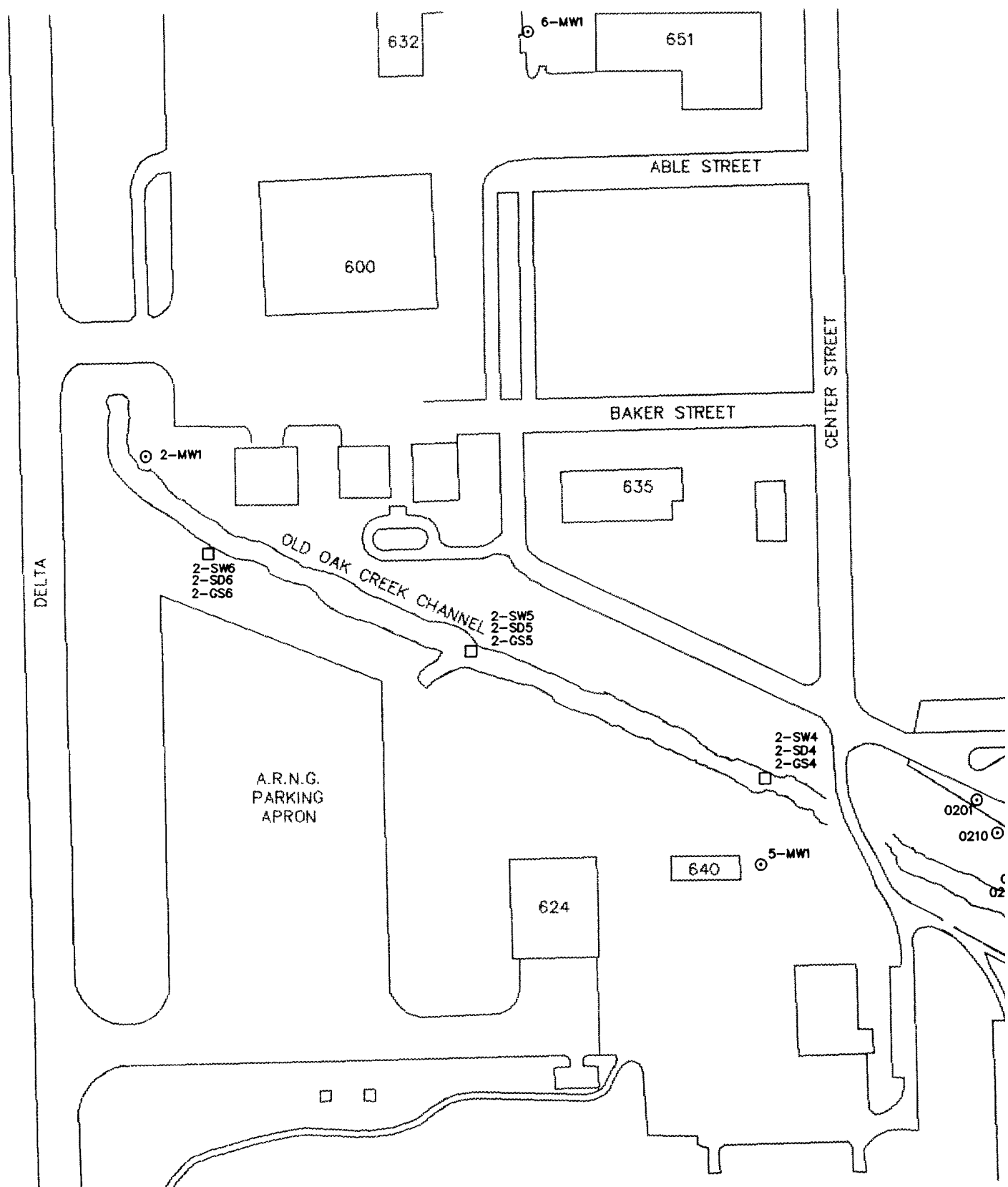
Four soil borings, 2-BH1, 3-BH1, 5-BH1, and 6-BH1, were advanced with a Mobile B-57 drill rig equipped with nominal 6-inch internal diameter, continuous-flight hollow-stem augers to depths between 21 and 24 feet below the ground surface. These borings are located in Sites 2, 3, 5, and 6 (Figure 3.1). Drilling began on 20 June 1989 and was completed by 26 June 1989. Two representative soil samples for chemical analysis were taken from boring 5-BH1 and three were taken from borings 3-BH1 and 6-BH1. Each boring penetrated approximately ten feet into the saturated zone. All four borings were converted into monitoring wells.

All drilling equipment was decontaminated upon arrival at the project site, between each borehole, and prior to leaving the project site. Decontamination procedures involved thoroughly steam-cleaning the drilling equipment, particularly the top head, draw works and table drive of the drill rig, in addition to all down-hole tools such as augers, drive casing, drill steel, drill bits, and depth sounding devices. Decontamination activities were performed at each boring and well location to prevent transportation of contaminants from one site to another.

3.2.1.2 Soil Sampling Procedures

A log of each boring, noting lithologies encountered and other pertinent information, was prepared by an onsite geologist. Soil samples for physical descriptive purposes were collected continuously with a split-spoon sampler. The geologic boring log included the following information:

- depth;
- profile;
- Unified Soil Classification System definition or characterization;
- geologic description;
- sample number (if appropriate);
- drill pressure/blow counts; and



LEGEND

△ RW-6

PRE-EXISTING RECOVERY WE

○ 0203

PRE-EXISTING MONITOR WEL

○ 2-MW1

ES MONITOR WELL INSTALLED

● 3-BH3

SOIL BORING

□ 2-SW3

SURFACE WATER SAMPLING

□ 2-SW3
2-SD3
2-SG3

SURFACE WATER SAMPLING,
SAMPLING, AND GAGING STA

~~~~~

OLD OAK CREEK CHANNEL B

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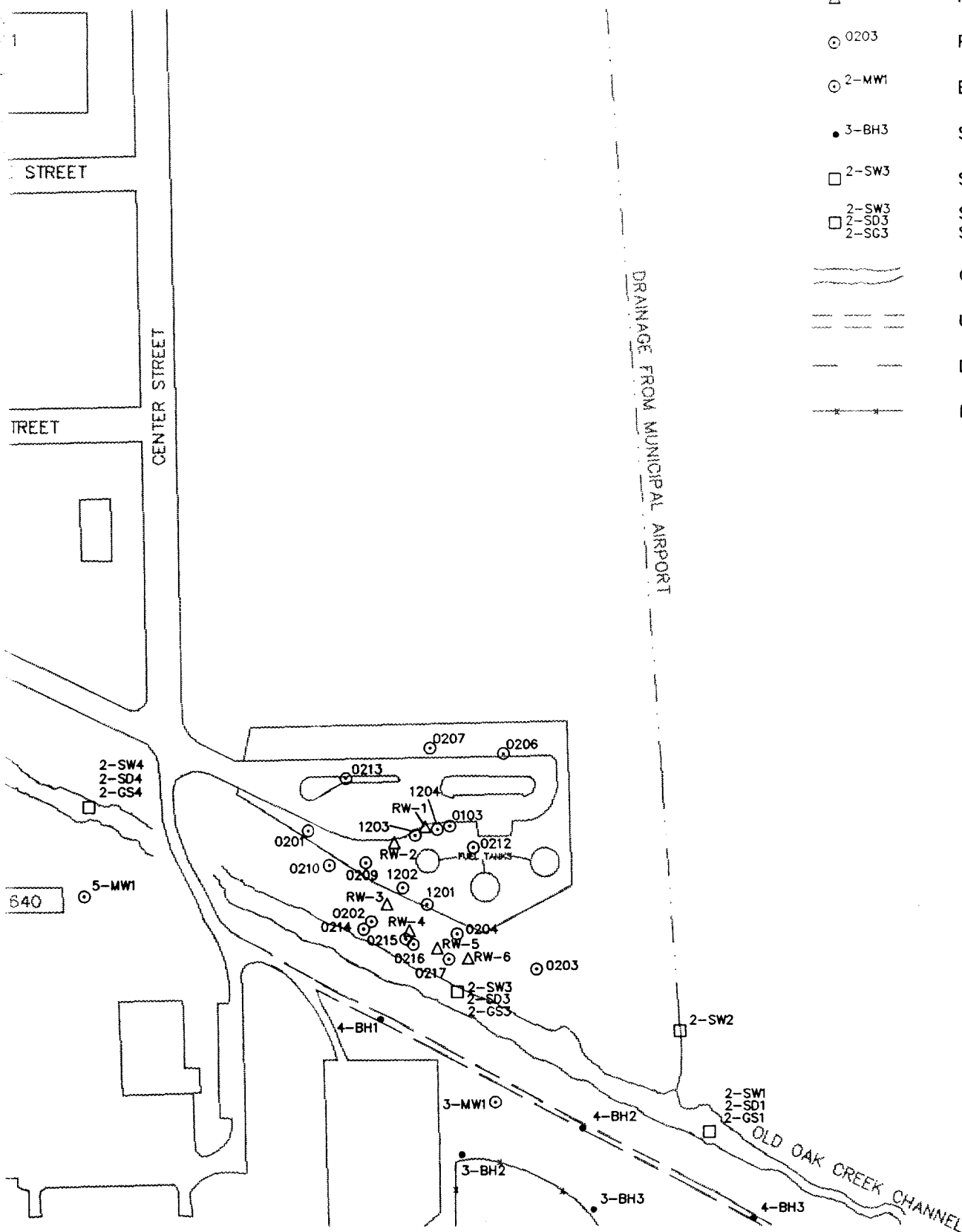
UNIMPROVED ROAD

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DRAINAGE CULVERT

-x-x-

FENCE



0 125

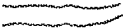
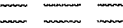

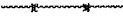
SAMPLI

155th Ai  
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Lincoln  
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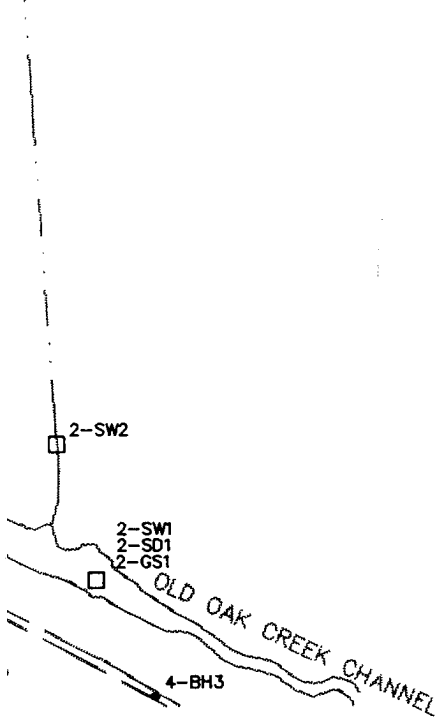
**PARSON ENGINEER**

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## LEGEND

|                                                                                   |                                                                              |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| △ RW-6                                                                            | PRE-EXISTING RECOVERY WELL                                                   |
| ○ 0203                                                                            | PRE-EXISTING MONITOR WELL                                                    |
| ⊙ 2-MW1                                                                           | ES MONITOR WELL INSTALLED 6/89                                               |
| ● 3-BH3                                                                           | SOIL BORING                                                                  |
| □ 2-SW3                                                                           | SURFACE WATER SAMPLING SITE                                                  |
| □ 2-SW3<br>2-SD3<br>2-SG3                                                         | SURFACE WATER SAMPLING, STREAM SEDIMENT<br>SAMPLING, AND GAGING STATION SITE |
|  | OLD OAK CREEK CHANNEL BOUNDARY                                               |
|  | UNIMPROVED ROAD                                                              |
|  | DRAINAGE CULVERT                                                             |
|  | FENCE                                                                        |

DRAINAGE FROM MUNICIPAL AIRPORT



**FIGURE 3.1**

### **SAMPLING LOCATIONS**

155th Air Refueling Group  
Nebraska Air National Guard  
Lincoln Municipal Airport  
Lincoln, Nebraska



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- remarks which include photoionization detector measurements, water table information, and any pertinent comments regarding drilling.

Soil samples from the borings were collected to determine the presence of soil contamination. Sampling intervals were dependent upon the depth and type of borehole. Soil samples collected within the first foot were defined as surface samples, and all deeper samples were defined as subsurface samples. In all, eighteen soil samples and two duplicates were collected and analyzed, including seven soil samples and one duplicate at Site 3; six soil samples and one duplicate at Site 4; two soil samples at Site 5; and three soil samples at Site 6. All soil samples were analyzed for petroleum hydrocarbons, heavy metals, and common anions. In addition, soil samples from Sites 3, 5, and 6 were analyzed for volatile and semivolatile organics, and samples from Site 4 were analyzed for PCBs.

Samples taken from the hand-augered boreholes for laboratory analysis were obtained between the surface and a depth of 1 foot and from 4 to 5 feet below the ground surface. Typically two or three borings within close proximity to one another were made at each location in Site 3 to obtain sufficient soil volume for chemical analysis. The hand-augered samples from Site 4 were taken from both sides of the road and composited.

Soil samples from the borings advanced by drilling were obtained between the ground surface and the top of the saturated zone. These soil samples were composited from a single borehole over 3- to 6-foot intervals. Compositing was necessary due to the small volume of the split-spoon samples relative to the volume of soil required for a sample by the analytical laboratory. Generally, all soil collected between the ground surface and the water table was incorporated into samples for laboratory analysis.

Soil samples for volatile organics analyses were collected directly in brass liners to avoid loss of volatile constituents. The exposed ends of the liners were covered with aluminum foil and capped with plastic caps taped in place. The soil in the liners was extruded at the laboratory prior to analysis. Soil samples for the remaining analytical parameters were transferred directly from the split-spoon sampler or bucket auger to the sample containers. Each sample was assigned a sample number and pertinent information was recorded in the field book. All soil samples, accompanied by a chain-of-custody form, were hand-carried to the analytical laboratory on the day of collection.

All equipment used for soil sampling, including the hand auger, split-spoon sampler, and sampler knives, were thoroughly decontaminated between each sample collection. The decontamination procedure included a detergent wash, tap water rinse, methanol rinse, and a second rinse with lab grade deionized water. Sufficient time was allowed following the final rinse to permit complete drying of the equipment.

### **3.2.1.3 Monitoring Well Construction and Completion**

Monitoring wells were constructed of 2-inch-diameter, Schedule 40, flush coupled-and-threaded polyvinyl chloride (PVC) casing and screen. As shown in the

well construction diagrams in Appendix B, each well consisted of a 2-foot-long unslotted sediment trap, a 10-foot-long screen, and a riser pipe. The screen slot size was 0.010 inch. All monitoring well casings, screens and fittings were decontaminated by steam cleaning before installation in the borehole.

The annular space between the well casing and the borehole was backfilled during removal of the augers and after the well casing was set in the borehole. The well annulus in three of the four wells was sandpacked from the bottom of the borehole to 3 feet above the top of the screen using a graded, washed, and bagged 4-40 silica sand. In Well 5-MW1, the sandpack extended 2 feet above the top of the screen in order to leave sufficient room for the overlying seal. A minimum 1- to 2-foot-thick seal of bentonite pellets was placed over the sand pack to separate it from the overlying grout seal. A neat concrete grout, with a maximum two percent by weight of bentonite, was placed from the top of the bentonite seal to within approximately 1 foot of the ground surface.

All monitoring wells were flush mounted with the ground surface. The well casings were cut 3 to 4 inches below ground surface and capped with a locking cap to prevent tampering and infiltration of surface water. A protective lid was cemented in place around the casing top. The protective lid was comprised of a cast-iron valve-box assembly centered in a 2-foot square concrete pad sloping away from the well. The lock keys were given to the base civil engineer. A diagram of each well completion is provided in Appendix B.

The monitoring wells were developed by removing approximately twenty well casing volumes of water using a teflon bailer. The temperature, pH, and EC of the development water were monitored and recorded during development. These parameters stabilized within 10 percent during well development. The water removed during well development was retained in labeled and sealed 55-gallon drums. Prior to development, water levels in each well were measured using an electric water-level indicator accurate to 0.01 feet.

All equipment used for well development was decontaminated prior to and after use at each well. The decontamination procedures included a detergent wash, tap water rinse, methanol rinse, and a second rinse with laboratory grade distilled and deionized water. Sufficient time was allowed following rinsing to permit complete drying.

#### **3.2.1.4 Surveying**

All existing and newly-installed monitoring wells and borehole locations on the base were surveyed to define their locations and elevations for future reference. Monitoring wells were located within  $\pm 0.01$  foot horizontally and  $\pm 0.01$  foot vertically. Boreholes were located within  $\pm 0.01$  foot horizontally, however, their elevations were not surveyed. These surveys were performed by Professional Surveyors, Inc. of Lincoln, Nebraska, a registered land surveyor.

#### **3.2.2 Ground Water Field Measurements and Sampling**

Ground water samples were collected from each well following well development. Additionally, samples were collected from seven existing monitoring

wells at Site 1, following purging. Purging records are included in Appendix B. A total of eleven samples of ground water from Sites 1, 2, 3, 5 and 6 were taken, along with one duplicate, one field blank, and three rinseate blanks. Each sample was analyzed for total petroleum hydrocarbons, volatile and semivolatile organics, common anions (sulfate, chloride, fluoride, nitrite, and nitrate), and metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver). Filtering of dissolved metals samples and preservation of metals samples with nitric acid (HNO<sub>3</sub>) were performed at the analytical laboratory following sample delivery. All samples were delivered to the laboratory within the same day of sample collection. A detailed description of analyses performed is included in Section 3.3.

Field measurements taken at the time of sample collection included temperature, pH, and EC. A mercury thermometer calibrated in degrees centigrade to the nearest 0.1 degree was used to record temperature. The water temperature measurements were used to calibrate the pH meter before testing and to determine the correction factor applied to the conductivity meter readings. The pH of the water was measured with a portable pH meter during sampling. The meter was calibrated daily using at least two buffer solutions of the appropriate range for expected pH values. Lot numbers and expiration dates of standards used were recorded in a bound, sequentially paginated field book. The EC of the water was measured with a portable EC meter. Each reading was corrected for temperature. A standard potassium chloride solution having an EC of 1,000 micromhos per centimeter ( $\mu\text{mhos/cm}$ ) was measured daily to detect and record variabilities in instrument readings. Lot numbers and expiration dates of the standards used were recorded. A record of each ground water sample was made in a bound, sequentially paginated field book. Samples delivered to the analytical laboratory were recorded on a chain-of-custody form.

Each piece of equipment used during sampling was thoroughly decontaminated between each sample and location. The decontamination procedures included a detergent wash, tap water rinse, methanol rinse, and a second rinse with laboratory grade deionized water. Sufficient time was allowed following rinsing to permit complete drying.

### **3.2.3 Surface Water Sampling**

Surface water samples were taken from the Old Oak Creek channel (Site 2), the only surface water present in the study area (Figure 3.1). Four of the five sampling stations in the Old Oak Creek channel were located adjacent to or downstream of outfalls draining into the creek. The fifth station was located adjacent to Site 1. The sixth sampling station was located in the culvert which conveys drainage from the municipal airport to the Old Oak Creek channel. A total of six surface water samples, one duplicate sample, and one rinseate blank were taken from Site 2. These samples were analyzed for volatile and semivolatile organics, petroleum hydrocarbons, common anions, and metals. Preservation of metals samples, and filtering of dissolved metals samples were performed at the analytical laboratory following sample delivery.

Field measurements including temperature, pH, and EC were measured at the time of sample collection according to the procedures described in Section 3.2.2. Surface water samples for volatile organics analysis were obtained by submerging the sample bottles at the centroid of the channel. Samples for petroleum hydrocarbons analysis were collected by dipping a decontaminated plastic beaker into the creek at three locations around the sampler and transferring the collected water into the sample containers. The sample locations were approximately 3 feet from the sampler. The remainder of the samples for metals and common anions were obtained by submerging the sample containers in the creek at three locations around the sampler. Approximately one-third of each sample was obtained at each of the three locations.

A record of each surface water sample was made in a bound, sequentially paginated field book. All samples delivered to the analytical laboratory were recorded on a chain-of-custody form.

The decontamination procedure for the surface water sampling equipment included a detergent wash, tap water rinse, methanol rinse, and a second rinse with laboratory grade deionized water. Sufficient time was allowed following the final rinse to permit complete drying of the equipment.

In addition to collecting water samples for chemical analysis, five staff gages were installed in the Old Oak Creek channel to measure the surface water elevation in the approximate locations of sample collection. Flow measurements could not be obtained due to the semi-stagnant nature of the channel. Each gage consisted of a 3- to 5-foot-long, Stevens-type staff gage attached to a metal post. Visual water level readings were made from the staff gage. The locations and elevations of the gages were surveyed for future reference. They were located to within  $\pm 0.01$  foot horizontally and  $\pm 0.01$  foot vertically. These surveys were performed by Professional Surveyors, Inc. of Lincoln, Nebraska, a registered land surveyor.

#### **3.2.4 Sediment Sampling**

In addition to the surface water samples removed from the Old Oak Creek channel, sediment samples were taken for chemical analysis. The purpose of obtaining these samples was to further investigate the potential for degradation in the channel. A total of five sediment samples and one duplicate sample were taken from Site 2. These samples were analyzed for volatile and semivolatile organics, petroleum hydrocarbons, common anions, and metals.

Sediment samples were collected using a decontaminated steel scoop equipped with a drain hole. Sediments were collected from three locations across an approximate 8-foot section of the creek width. The drained sediments were composited in a stainless steel mixing bowl using a stainless steel trowel and transferred from the bowl to the sample containers. Sediment samples for volatile organics analysis were transferred directly from the sampling scoop to the sample container to minimize the loss of volatile compounds. A record of the sediment sampling was made in a bound, sequentially paginated field book. Additionally, each sample was recorded on a chain-of-custody form prior to relinquishing it to the analytical laboratory.

The equipment used for sediment sampling was thoroughly decontaminated between each sample and sample site. All equipment was decontaminated by a detergent wash, tap water rinse, methanol rinse, and a second rinse of laboratory grade deionized water. Sufficient time was allowed following the final rinse to permit complete drying of the equipment.

### **3.3 ANALYTICAL PROGRAM**

#### **3.3.1 Detection Limits**

Detection limits for quantitation of each parameter per matrix and corresponding analytical method are shown in Appendix E. Detection limits for certain parameters may vary with the analytical method used due to matrix effects, sample dilutions, and soil matrix percent moisture composition.

#### **3.3.2 Parameters**

Specific chemical parameters for the sampling programs discussed above were selected based on contaminants suspected on the Nebraska ANGB property. The analytical program involved analyzing samples by the methods specified in Table 3.2. Analytes for each method are listed in Tables 3.3 through 3.7.

#### **3.3.3 Data Quality Indicators**

The analytical data were evaluated in accordance with the HAZWRAP Requirements for Quality Control of Analytical Data (Oak Ridge Gaseous Diffusion Plant, 1988) and the quality assurance section of the Nebraska ANGB site investigation work plan (Engineering-Science, Inc., 1989). Laboratory QC data were reviewed for HAZWRAP Level C validation, and affected associated sample data were validated and coded with quality indicator flags. Specific sample analytes traceable to QC violations were validated as estimated (flagged "J") or unusable (flagged "R"), based on the severity of the QC violation.

Any data value that did not require qualification (e.g., data reported as a numeric value with no associated alphanumeric character) is both a reliable indicator of the presence of the compound and an accurate estimate of its concentration.

Data qualified by a "J" value indicate that the laboratory analysis positively identified the presence of the compound but the reported concentration of the compound is an estimated value. The "J" qualifier does not imply any quantitative range on the accuracy of the estimate nor does it mean the reported value is necessarily less accurate than unqualified data. However, data qualified by an "R" value indicate that the compound may or may not be present and the associated data are unusable. Resampling and/or reanalysis is necessary for verification.

All data qualified as either "U" or "UJ" indicate that the compound was not present at a concentration equal to or greater than the reported detection limit.

The data validation summary is provided in Appendix D9.

TABLE 3.2

ANALYTICAL METHOD SUMMARY  
155th AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

| Site | Analytes <sup>a/</sup>                                                                       | Analysis Method <sup>b/</sup>                                              |                                                                               |
|------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-------------------------------------------------------------------------------|
|      |                                                                                              | Soil                                                                       | Water                                                                         |
| 1    | Volatile organics<br>Semivolatile organics<br>Petroleum hydrocarbons<br>Metals<br><br>Anions |                                                                            | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3010/3020;<br>6010/7000<br>SMA429 |
| 2    | Volatile organics<br>Semivolatile organics<br>Petroleum hydrocarbons<br>Metals<br><br>Anions | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3050;<br>6010/7000<br>SMA375.2 | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3010/3020;<br>6010/7000<br>SMA429 |
| 3    | Volatile organics<br>Semivolatile organics<br>Petroleum hydrocarbons<br>Metals<br><br>Anions | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3050;<br>6010/7000<br>SMA375.2 | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3010/3020;<br>6010/7000<br>SMA429 |
| 4    | Petroleum hydrocarbons<br>PCBs<br>Metals<br><br>Anions                                       | EPA418.1<br>SW8080<br>SW3050;<br>6010/7000<br>SMA375.2                     |                                                                               |
| 5    | Volatile organics<br>Semivolatile organics<br>Petroleum hydrocarbons<br>Metals<br><br>Anions | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3050;<br>6010/7000<br>SMA375.2 | EPA624-CLPM<br>EPA625-CLPM<br>EPA418.1<br>SW3010/3020;<br>6010/7000<br>SMA429 |



TABLE 3.2 (Continued)

ANALYTICAL METHOD SUMMARY  
155th AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

| Site | Analytes <sup>a/</sup>                                                         | Analysis Method <sup>b/</sup>                        |                                                                       |
|------|--------------------------------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------------|
|      |                                                                                | Soil                                                 | Water                                                                 |
| 6    | Volatile organics<br>Semivolatile organics<br>Petroleum hydrocarbons<br>Metals | EPA624<br>EPA625<br>EPA418.1<br>SW3050;<br>6010/7000 | EPA624-CLP-M<br>EPA625-CLP-M<br>EPA418.1<br>SW3010/3020;<br>6010/7000 |
|      | Anions                                                                         | SMA375.2                                             | SMA429                                                                |

<sup>a/</sup> Specific Analytes are listed by method in Table 3.2.

<sup>b/</sup> Method Sources:

- . SW - U.S. Environmental Protection Agency (1986d).
- . EPA - U.S. Environmental Protection Agency (1983b).
- . EPA-CLPM - U.S. Environmental Protection Agency (1988).
- . SM - American Public Health Association et al. (1985).

TABLE 3.3  
VOLATILE ORGANICS ANALYZED BY METHOD AND MEDIUM  
155th AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits<sup>a/</sup>

**Volatile Organics - Method EPA624-CLPM**

| Volatiles                  | CAS Number | Quantitation Limits <sup>b/</sup> |                            |
|----------------------------|------------|-----------------------------------|----------------------------|
|                            |            | Water<br>µg/L                     | Low Soil/Sediment<br>µg/Kg |
| Chloromethane              | 74-87-3    | 10                                | 10                         |
| Bromomethane               | 74-83-9    | 10                                | 10                         |
| Vinyl chloride             | 75-01-4    | 10                                | 10                         |
| Chloroethane               | 75-00-3    | 10                                | 10                         |
| Methylene chloride         | 75-09-2    | 5                                 | 5                          |
| Acetone                    | 67-64-1    | 10                                | 10                         |
| Carbon disulfide           | 75-15-0    | 5                                 | 5                          |
| 1,1-Dichloroethene         | 75-35-4    | 5                                 | 5                          |
| 1,1-Dichloroethane         | 75-34-3    | 5                                 | 5                          |
| 1,2-Dichloroethene (total) | 540-59-0   | 5                                 | 5                          |
| Chloroform                 | 67-66-3    | 5                                 | 5                          |
| 1,2-Dichloroethane         | 107-06-2   | 5                                 | 5                          |
| 2-Butanone                 | 78-93-3    | 10                                | 10                         |
| 1,1,1-Trichloroethane      | 71-55-6    | 5                                 | 5                          |
| Carbon tetrachloride       | 56-23-5    | 5                                 | 5                          |
| Vinyl acetate              | 108-05-4   | 10                                | 10                         |
| Bromodichloromethane       | 75-27-4    | 5                                 | 5                          |
| 1,2-Dichloropropane        | 78-87-5    | 5                                 | 5                          |
| cis-1,3-Dichloropropene    | 10061-01-5 | 5                                 | 5                          |
| Trichloroethene            | 79-01-6    | 5                                 | 5                          |
| Dibromochloromethane       | 124-48-1   | 5                                 | 5                          |
| 1,1,2-Trichloroethane      | 79-00-5    | 5                                 | 5                          |
| Benzene                    | 71-43-2    | 5                                 | 5                          |
| trans-1,3-Dichloropropene  | 10061-02-6 | 5                                 | 5                          |
| Bromoform                  | 75-25-2    | 5                                 | 5                          |
| 4-Methyl-2-pentanone       | 108-10-1   | 10                                | 10                         |
| 2-Hexanone                 | 591-78-6   | 10                                | 10                         |
| Tetrachloroethene          | 127-18-4   | 5                                 | 5                          |
| Toluene                    | 108-88-3   | 5                                 | 5                          |
| 1,1,2,2-Tetrachloroethane  | 79-34-5    | 5                                 | 5                          |

TABLE 3.3 (Continued)  
VOLATILE ORGANICS ANALYZED BY METHOD AND MEDIUM  
155th AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits <sup>a/</sup>

**Volatile Organics - Method EPA624-CLPM**

| Volatiles       | CAS Number | Quantitation Limits <sup>b/</sup> |                                          |
|-----------------|------------|-----------------------------------|------------------------------------------|
|                 |            | <u>Water</u><br><u>µg/L</u>       | <u>Low Soil/Sediment</u><br><u>µg/Kg</u> |
| Chlorobenzene   | 108-90-7   | 5                                 | 5                                        |
| Ethyl benzene   | 100-41-4   | 5                                 | 5                                        |
| Styrene         | 100-42-5   | 5                                 | 5                                        |
| Xylenes (Total) | 1330-20-7  | 5                                 | 5                                        |

a/ Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

b/ Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

TABLE 3.4  
SEMIVOLATILE ORGANICS ANALYZED BY METHOD AND MEDIUM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits<sup>a/</sup>

**Semivolatile Organics - Method EPA625-CLPM**

| Semivolatiles                                         | CAS Number | Quantitation Limits <sup>b/</sup> |                                                 |
|-------------------------------------------------------|------------|-----------------------------------|-------------------------------------------------|
|                                                       |            | <u>Water</u><br>μg/L              | <u>Low Soil/Sediment</u> <sup>c/</sup><br>μg/Kg |
| Phenol                                                | 108-95-2   | 10                                | 170                                             |
| bis(2-chloroethyl) ether                              | 111-44-4   | 10                                | 170                                             |
| 2-Chlorophenol                                        | 95-57-8    | 10                                | 170                                             |
| 1,3-Dichlorobenzene                                   | 541-73-1   | 10                                | 170                                             |
| 1,4-Dichlorobenzene                                   | 106-46-7   | 10                                | 170                                             |
| Benzyl alcohol                                        | 100-51-6   | 10                                | 170                                             |
| 1,2-Dichlorobenzene                                   | 95-50-1    | 10                                | 170                                             |
| 2-Methylphenol                                        | 95-48-7    | 10                                | 170                                             |
| bis(2-chloroisopropyl) ether                          | 108-60-1   | 10                                | 170                                             |
| 4-Methylphenol                                        | 106-44-5   | 10                                | 170                                             |
| N-Nitroso-di-n-dipropylamine                          | 621-64-7   | 10                                | 170                                             |
| Hexachloroethane                                      | 67-72-1    | 10                                | 170                                             |
| Nitrobenzene                                          | 98-95-3    | 10                                | 170                                             |
| Isophorone                                            | 78-59-1    | 10                                | 170                                             |
| 2-Nitrophenol                                         | 88-75-5    | 10                                | 170                                             |
| 2,4-Dimethylphenol                                    | 105-67-9   | 10                                | 170                                             |
| Benzoic acid                                          | 65-85-0    | 50                                | 830                                             |
| bis(2-Chloroethoxy) methane                           | 111-91-1   | 10                                | 170                                             |
| 2,4-Dichlorophenol                                    | 120-83-2   | 10                                | 170                                             |
| 1,2,4-Trichlorobenzene                                | 120-82-1   | 10                                | 170                                             |
| Naphthalene                                           | 91-20-3    | 10                                | 170                                             |
| 4-Chloroaniline                                       | 106-47-8   | 10                                | 170                                             |
| Hexachlorobutadiene                                   | 87-68-3    | 10                                | 170                                             |
| 4-Chloro-3-methylphenol<br>(para-chloro-metal-cresol) | 59-50-7    | 10                                | 170                                             |
| 2-Methylnaphthalene                                   | 91-57-6    | 10                                | 170                                             |
| Hexachlorocyclopentadiene                             | 77-47-4    | 10                                | 170                                             |
| 2,4,6-Trichlorophenol                                 | 88-06-2    | 10                                | 170                                             |
| 2,4,5-Trichlorophenol                                 | 95-95-4    | 50                                | 830                                             |
| 2-Chloronaphthalene                                   | 91-58-7    | 10                                | 170                                             |
| 2-Nitroaniline                                        | 88-74-4    | 50                                | 830                                             |

TABLE 3.4 (Continued)  
SEMIVOLATILE ORGANICS ANALYZED BY METHOD AND MEDIUM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits<sup>a/</sup>

**Semivolatile Organics - Method EPA625-CLPM**

| Semivolatiles               | CAS Number | Quantitation Limits <sup>b/</sup> |                                          |
|-----------------------------|------------|-----------------------------------|------------------------------------------|
|                             |            | Water<br>μg/L                     | Low Soil/Sediment <sup>c/</sup><br>μg/Kg |
| Dimethylphthalate           | 131-11-3   | 10                                | 170                                      |
| Acenaphthylene              | 208-96-8   | 10                                | 170                                      |
| 2,6-Dinitrotoluene          | 606-20-2   | 10                                | 170                                      |
| 3-Nitroaniline              | 99-09-2    | 50                                | 830                                      |
| Acenaphthene                | 83-32-9    | 10                                | 170                                      |
| 2,4-Dinitrophenol           | 51-28-5    | 50                                | 830                                      |
| 4-Nitrophenol               | 100-02-7   | 50                                | 830                                      |
| Dibenzofuran                | 132-64-9   | 10                                | 170                                      |
| 2,4-Dinitrotoluene          | 121-14-2   | 10                                | 170                                      |
| Diethylphthalate            | 84-66-2    | 10                                | 170                                      |
| 4-Chlorophenyl-phenyl ether | 7005-72-3  | 10                                | 170                                      |
| Fluorene                    | 86-73-7    | 10                                | 170                                      |
| 4-Nitroaniline              | 100-01-6   | 50                                | 830                                      |
| 4,6-Dinitro-2-methylphenol  | 534-52-1   | 50                                | 830                                      |
| N-nitrosodiphenylamine      | 86-30-6    | 10                                | 170                                      |
| 4-Bromophenyl-phenylether   | 101-55-3   | 10                                | 170                                      |
| Hexachlorobenzene           | 118-74-1   | 10                                | 170                                      |
| Pentachlorophenol           | 87-86-5    | 50                                | 830                                      |
| Phenanthrene                | 85-01-8    | 10                                | 170                                      |
| Anthracene                  | 120-12-7   | 10                                | 170                                      |
| Di-n-butylphthalate         | 84-74-2    | 10                                | 170                                      |
| Fluoranthene                | 206-44-0   | 10                                | 170                                      |
| Pyrene                      | 129-00-0   | 10                                | 170                                      |
| Butylbenzylphthalate        | 85-68-7    | 10                                | 170                                      |
| 3,3'-Dichlorobenzidine      | 91-94-1    | 20                                | 340                                      |
| Benzo(a)anthracene          | 56-55-3    | 10                                | 170                                      |
| Chrysene                    | 218-01-9   | 10                                | 170                                      |
| bis(2-Ethylhexyl)phthalate  | 117-81-7   | 10                                | 170                                      |
| Di-n-octylphthalate         | 117-84-0   | 10                                | 170                                      |
| Benzo(b)fluoranthene        | 205-99-2   | 10                                | 170                                      |

TABLE 3.4 (Continued)  
SEMIVOLATILE ORGANICS ANALYZED BY METHOD AND MEDIUM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits<sup>a/</sup>

**Semivolatile Organics - Method EPA625-CLPM**

| Semivolatiles           | CAS Number | Quantitation Limits <sup>b/</sup> |                                                            |
|-------------------------|------------|-----------------------------------|------------------------------------------------------------|
|                         |            | <u>Water</u><br>$\mu\text{g/L}$   | <u>Low Soil/Sediment</u> <sup>c/</sup><br>$\mu\text{g/Kg}$ |
| Benzo(k)fluoranthene    | 207-08-9   | 10                                | 170                                                        |
| Benzo(a)pyrene          | 50-32-8    | 10                                | 170                                                        |
| Indeno (1,2,3-cd)pyrene | 193-39-5   | 10                                | 170                                                        |
| Dibenz(a,h)anthracene   | 53-70-3    | 10                                | 170                                                        |
| Benzo(g,h,i)perylene    | 191-24-2   | 10                                | 170                                                        |

- a/ Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.
- b/ Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated the laboratory for soil/sediment calculated on dry weight basis as required by the contract will be higher.
- c/ Laboratory reported detection limits (DLs) are a factor of 0.5 lower than the method required DLs.

TABLE 3.5  
POLYCHLORINATED BIPHENYLS (PCBs) ANALYZED BY METHOD AND MEDIUM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits<sup>a/</sup>

SW 8080

| PCBs         | CAS Number | Quantitation Limits <sup>b/</sup> |                            |
|--------------|------------|-----------------------------------|----------------------------|
|              |            | Water<br>μg/L                     | Low Soil/Sediment<br>μg/Kg |
| Aroclor-1016 | 12674-11-2 | -- <sup>c/</sup>                  | 1.6                        |
| Aroclor-1221 | 11104-28-2 | --                                | 1.6                        |
| Aroclor-1232 | 11141-16-5 | --                                | 1.6                        |
| Aroclor-1242 | 53469-21-9 | --                                | 1.6                        |
| Aroclor-1248 | 12672-29-6 | --                                | 1.6                        |
| Aroclor-1254 | 11097-69-1 | --                                | 3.2                        |
| Aroclor-1260 | 11096-82-5 | --                                | 3.2                        |

a/ Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are those provided by the laboratory. EPA Method SW8080 does not list practical quantitation limits for PCB compounds.

b/ Quantitation limits listed for soil/sediment are based on wet weight. The quantitation limits calculated by the laboratory for soil/sediment, calculated on dry weight basis as required by the contract, will be higher.

c/ Water matrix samples were not analyzed for PCBs.

TABLE 3.6  
HEAVY METALS ANALYZED BY METHOD AND MEDIUM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

Target Compound List (TCL) and  
Laboratory Reported Quantitation Limits (CRDL)<sup>a/</sup>

**SW 6010/7000  
RCRA Heavy Metals<sup>b/</sup>**

| SW 6010/7000<br>RCRA Heavy Metals <sup>b/</sup> |    | Quantitation Limits <sup>c/</sup> |                      |                                   |
|-------------------------------------------------|----|-----------------------------------|----------------------|-----------------------------------|
| Dissolved and Total Metals <sup>d/</sup>        |    | CAS Number                        | <u>Water</u><br>µg/L | <u>Low Soil/Sediment</u><br>mg/Kg |
| <u>Instrument<sup>e/</sup></u>                  |    |                                   |                      |                                   |
| Arsenic (As)                                    | F  | 7440-38-2                         | 10                   | 1.0                               |
| Barium (Ba)                                     | P  | 7440-39-3                         | 200                  | 20.0                              |
| Cadmium (Cd)                                    | F  | 7440-43-9                         | 5                    | 0.5                               |
| Chromium (Cr)                                   | P  | 7440-47-3                         | 10                   | 1.0                               |
| Lead (Pb)                                       | F  | 7439-92-1                         | 3                    | 0.3                               |
| Mercury (Hg)                                    | CV | 7439-97-6                         | 0.02                 | 0.2                               |
| Selenium (Se)                                   | F  | 7782-49-2                         | 5                    | 0.5                               |
| Silver (Ag)                                     | F  | 7440-22-4                         | 10                   | 1.0                               |

a/ The documented instrument or method detection limits (DLs) must meet the Contract Required Detection Limit (CRDL) requirements. Higher detection limits may be used in circumstances when the sample concentration exceeds five times the DL of the instrument or method in use.

b/ Water matrix samples were filtered and acidified to a pH <2 with HNO<sub>3</sub> prior to analytical sample preparation; dissolved metal concentrations are reported for water matrix samples; total metal concentrations are reported for soil matrix samples.

c/ The quantitation limit CRDLs are the instrument detection limits obtained in pure water that must be used using the analytical procedure. The DLs for samples may be considerably higher depending on the sample matrix.

d/

| Analyte | Dissolved Metals<br>Preparation/Analysis<br>(Water Matrix Samples) | Total Metals<br>Preparation/Analysis<br>(Soil Matrix Samples) |
|---------|--------------------------------------------------------------------|---------------------------------------------------------------|
|         |                                                                    |                                                               |
| As      | SW 3020/7060                                                       | SW 3050/7060                                                  |
| Ba      | SW 3010/6010                                                       | SW 3050/6010                                                  |
| Cd      | SW 3020/7131                                                       | SW 3050/7131                                                  |
| Cr      | SW 3010/6010                                                       | SW 3050/6010                                                  |
| Pb      | SW 3020/7421                                                       | SW 3050/7421                                                  |
| Hg      | SW 7470                                                            | SW 7471                                                       |
| Se      | SW 3020/7740                                                       | SW 3050/7740                                                  |
| Ag      | SW 3020/7761                                                       | SW 3050/7761                                                  |

e/ Instrumental Method Codes: CV-Manual Cold Vapor AA; F-Furnace AA; P-ICP.



TABLE 3.7  
 PETROLEUM HYDROCARBONS ANALYZED BY METHOD AND MEDIUM  
 155TH AIR REFUELING GROUP  
 NEBRASKA AIR NATIONAL GUARD  
 LINCOLN MUNICIPAL AIRPORT  
 LINCOLN, NEBRASKA

| Petroleum Hydrocarbons        |                                             | <u>Quantitation Limits</u> |                                   |
|-------------------------------|---------------------------------------------|----------------------------|-----------------------------------|
| <u>Method</u><br>(water/soil) | <u>Analytes</u>                             | <u>Water</u><br>mg/L       | <u>Low Soil/Sediment</u><br>mg/Kg |
| EPA 418.1                     | Total recoverable<br>petroleum hydrocarbons | 1.0                        | 50.0                              |
| <b>Anions</b>                 |                                             |                            |                                   |
| SMA 429/375.2                 | Fluoride                                    | 0.05                       | 10.0                              |
|                               | Chloride                                    | 0.1                        | 10.0                              |
|                               | Nitrite                                     | 0.1                        | 10.0                              |
|                               | Nitrate                                     | 0.1                        | 10.0                              |
|                               | Sulfate                                     | 0.1                        | 10.0                              |

### **3.4 SITE-SPECIFIC FIELD INVESTIGATION PROGRAM**

The objective of the SI is to confirm or deny the presence of contamination within six sites at Nebraska ANGB and the field investigations were designed to achieve this goal. Site-specific investigative activities conducted at each of the six sites at Nebraska ANGB are summarized by site in the following paragraphs. Table 3.8 identifies sampling and drilling activities by site.

#### **3.4.1 Site 1 - POL Storage Area**

No new borings were drilled at this site. Water levels were measured in 25 existing wells, and the presence or absence of free product was determined. With the exception of well MW205, which could not be located, all existing wells were surveyed, and selected wells were purged, and sampled for laboratory analysis. Survey data is contained in Appendix C. The objective of the sampling program was to obtain ground water samples from six existing wells located downgradient (south and west) of the fuel tanks. Well 1203, located north of the tanks, was sampled in place of downgradient well 1201, which contained free product. A background well was not installed as proposed in the SI work plan because existing well 0206 was demonstrated to be upgradient and served as a background well. This well was sampled to obtain background water quality data.

#### **3.4.2 Site 2 - Old Oak Creek Channel**

Five surface water gaging stations were installed at Site 2, and water and sediment samples from each station were collected for analysis. In addition, a water sample was collected from the municipal airport drainage outfall. The locations and elevations of the staff gages were surveyed (see Appendix C), and surface water elevations were recorded at the time of sampling. One background well was installed to a depth of 23 feet. The well was surveyed, the water level was measured, and a water sample was collected for analysis.

#### **3.4.3 Site 3 - Former Tank Cleaning Area**

At Site 3, a 24-foot-deep boring was drilled and converted to a monitoring well. Two other 5-foot-deep borings were also hand-augered. Soil samples for lithologic characterization and laboratory analysis were collected from each of the three borings. In addition, the well was surveyed, the water level was measured, and a ground water sample was collected for analysis.

#### **3.4.4 Site 4 - South Rock Road**

Three 5-foot-deep borings were hand augered and soil samples were collected for lithologic characterization and laboratory analysis. The holes were backfilled with cuttings following sampling.

#### **3.4.5 Site 5 - Army National Guard Oil Storage Area**

One boring was drilled to a depth of 21 feet and converted to a monitoring well. The well was surveyed and a water level measurement and sample were taken. Soil samples were collected for lithologic characterization and laboratory analysis.

TABLE 3.8

DESCRIPTION OF SITE INVESTIGATION (SI) FIELD ACTIVITIES  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

| Site Number and Name                                            | Field Activities                                                                                                                                                                                                                                                                                                                                                                                                                                  | Analyses and Sampling Media                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Site 1 - Fuel Farm; Petroleum, Oils and Lubricants Storage Area | <ul style="list-style-type: none"> <li>Surveyed well head elevations of 19 existing wells and measured water levels.</li> <li>Sampled and analyzed 7 existing wells positioned south, east and west of the POL tank farm.</li> </ul>                                                                                                                                                                                                              | <p>A total of 10 water samples consisting of 7 well samples, 1 rinseate blank, 1 field blank, and 1 field duplicate were analyzed for volatile organics (EPA624-CLPM), semivolatile organics<sup>a/</sup> (EPA625-CLPM) petroleum hydrocarbons (EPA418.1), heavy metals<sup>a/</sup> (SW3010/3020;6010/7000), and common anions<sup>b/</sup> (SMA429). A trip blank was analyzed for volatile organics (EPA624-CLPM).</p>                                                                                                                               |
| Site 2 - West End of Old Oak Creek                              | <ul style="list-style-type: none"> <li>Sampled and analyzed 5 sediment and 6 surface water samples.</li> <li>Established staff gaging stations at 5 sampling stations in Old Oak Creek Channel surveyed staff gage elevations, and recorded surface water elevations during sampling.</li> <li>Installed 1 23-foot background well and surveyed well head elevation. Monitored static water level and collected a ground water sample.</li> </ul> | <p>A total of 6 sediment samples and 10 water samples consisting of 5 sediment samples plus 1 field duplicate, 6 surface water samples plus 1 rinseate blank and 1 field duplicate, and 1 ground water sample plus 1 rinseate blank were analyzed for volatile organics (EPA624-CLPM), semivolatile organics (EPA625-CLPM), petroleum hydrocarbons (EPA418.1), heavy metals<sup>a/</sup> (SW3010/3020/3050; 6010/7000), and common anions<sup>b/</sup> (SMA 429/375.2). In addition, 1 trip blank was analyzed for volatile organics (EPA624-CLPM).</p> |
| Site 3 - Former Tank Cleaning/Hazardous Waste Storage Area      | <ul style="list-style-type: none"> <li>Drilled 2 5-foot soil borings and collected split spoon samples from surface and bottom of each hole. Drilled 1 24-foot soil boring and collected continuous split spoon samples. Converted the boring to a monitor well and surveyed well head elevation. Measured static water level and collected a ground water sample.</li> <li>Analyzed 7 soil and 1 ground water samples.</li> </ul>                | <p>A total of 8 soil samples consisting of 7 soil samples plus 1 field duplicate, and 1 water sample consisting of 1 well sample were analyzed for volatile organics (EPA624-CLPM), semivolatile organics (EPA625-CLPM), petroleum hydrocarbons (EPA418.1), heavy metals<sup>a/</sup> (SW3010/3020/3050;6010/7000), and common anions<sup>b/</sup> (SMA429/375.2).</p>                                                                                                                                                                                  |

TABLE 3.8 (Continued)

DESCRIPTION OF SITE INVESTIGATION (SI) FIELD ACTIVITIES  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

| Site Number and Name                                | Field Activities                                                                                                                                                                                                                                                                                                                     | Analyses and Sampling Media                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Site 4 - Access Road, Dust Control Area             | <ul style="list-style-type: none"> <li>Drilled 3 5-foot soil borings and collected split spoon samples from the surface and bottom of each hole.</li> </ul>                                                                                                                                                                          | A total of 7 soil samples, consisting of 6 soil samples, plus 1 field duplicate were analyzed for petroleum hydrocarbons (EPA418.1), PCBs (SW8080), heavy metals <sup>a/</sup> (SW3050;6010/7000), and common anions <sup>b/</sup> (SMA375.2).                                                                                                                                                                                      |
| Site 5 - Army National Guard Oil Storage Area 640   | <ul style="list-style-type: none"> <li>Drilled 1 21-foot soil boring and collected continuous split spoon samples.</li> <li>Converted soil boring to monitor well and surveyed well head elevation. Measured static water level and collected a ground water sample.</li> <li>Analyzed 2 soil and 2 ground water samples.</li> </ul> | A total of 2 soil samples, and 2 water samples, consisting 1 well sample, plus 1 rinseate blank were analyzed for volatile organics (EPA624-CLPM), semivolatile organics (EPA625-CLPM), petroleum hydrocarbons (EPA418.1), heavy metals <sup>a/</sup> (SW3010/3020/3050;6010/7000), and common anions <sup>b/</sup> (SMA429/375.2). In addition, 1 trip blank was analyzed for volatile organics (EPA624-CLPM).                     |
| Site 6 - Hydraulic Pressure Check Unit Storage Area | <ul style="list-style-type: none"> <li>Drilled 1 22-foot soil boring and collected continuous split spoon samples.</li> <li>Converted boring to a monitor well and surveyed well head elevation. Measured static water level and collected a ground water sample.</li> <li>Analyzed 3 soil and 1 ground water samples.</li> </ul>    | A total of 3 soil samples, and 1 water sample, consisting of 1 well sample were analyzed for volatile organics (EPA624-CLPM), semivolatile organics (EPA625-CLPM), petroleum hydrocarbons (EPA418.1), and heavy metals <sup>a/</sup> (SW3010/3020/3050; 6010/7000). In addition, a field blank of tap water used in bore hole stabilization and decontamination of drilling equipment was analyzed for the above-listed parameters. |

<sup>a/</sup> Heavy metals include arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver.

<sup>b/</sup> Common anions include SO<sub>4</sub>, Cl, F, NO<sub>3</sub>, NO<sub>2</sub>.

### **3.4.6 Site 6 - Hydraulic Fluid Spill Area**

One boring was drilled to a depth of 22 feet and converted to a monitoring well. The well was surveyed and a water level measurement was taken. Soil samples were collected for lithologic characterization and laboratory analysis. A ground water sample was also collected for analysis.

## **3.5 QUALITY CONTROL PROGRAM**

### **3.5.1 Sample Integrity**

Strict sample numbering, documentation, handling and packaging, and custody procedures were followed during all phases of the field program to ensure sample integrity.

#### **3.5.1.1 Sample Numbering**

The sample numbering system provided a formal method for identification of each sample in order to allow retrieval of site-specific analytical information. Each sample was assigned a unique identification code consisting of five groups of letters and numbers, separated by hyphens, that corresponded to project identification; site identification; sample location; sample type; and sample number. Details of the identification system as well as an example sample number are described in Table 3.9.

#### **3.5.1.2 Sample Documentation**

Immediately following the collection of each sample, sample documentation was entered by the field teams in bound field log books. The log books provided a daily record of significant events, observations, and measurements which occurred during the field investigation. All entries were dated and signed.

Entries in the field log book included at least the following:

- . name of author, date and time of entry, and physical/environmental conditions during field activity;
- . purpose of sampling activity;
- . location of sampling activity;
- . name of field contact;
- . names of field crew members;
- . type of sampled media (e.g., soil, sediment, ground water, etc.);
- . sample collection method;
- . number and volume of sample(s) taken;
- . description of sampling point(s);
- . date and time of collection;
- . sample identification number(s) which included identification of coded duplicate samples;

TABLE 3.9

SAMPLE IDENTIFICATION SYSTEM  
155TH AIR REFUELING GROUP  
NEBRASKA AIR NATIONAL GUARD  
LINCOLN MUNICIPAL AIRPORT  
LINCOLN, NEBRASKA

---

Project Identification

LANGB - (Lincoln Air National Guard Base)

Site Identification

The Site Number and Name

Sample Location

BH - Borehole Number  
MW - Monitoring Well Number

Sample Type

SS - Soil Sample  
SD - Sediment Sample  
GW - Ground Water Sample  
SW - Surface Water Sample

Sample Number:

Sample Number (sequential for each sampling event)

Example Sample Number:

LANGB-2-BH1-SS-1: Lincoln ANGB, Site 2-Borehole Number 1, Soil  
Sample Number 1.

Sample Depth

Depth below grade, measured in feet, is noted on the label for soil samples.

---

Source: Engineering-Science, Inc.

- . field observations; and
- . any field measurements made, such as pH, water level, etc.

Original data were recorded in field log books, on sample labels, and on chain-of-custody records with waterproof ink. None of the field log books were destroyed or thrown away, even if they were illegible or contained errors. Errors were corrected by drawing a single line through the error and entering the correct information. The erroneous information remained legible. The person correcting the error also initialed and dated the change.

### **3.5.1.3 Sample Handling and Packaging**

The sample handling and packaging procedures ensured that the samples and their containers did not represent an avenue for personnel and environmental exposure and that the chemical character of the sample was representative of site conditions. For each sample collected, the collection point or points, depth increment of samples collected, and sampling devices used were identified and documented. The sample identification information, date, time, and names or initials of all sampling personnel were recorded in the field in the log book and on sample labels and applicable field record sheets. The sample labels were placed on the sample containers and covered with clear plastic tape. Samples were then placed in the appropriate containers. Disposable protective gloves were worn by all individuals involved in sample preparation. Glass bottles were wrapped completely in bubble-pack, and placed in a cooler filled with ice. Cooler contents were checked against the chain-of-custody record, the original of which was placed in a plastic bag and taped inside the cooler lid. The cooler drain was taped shut, and the lid was secured by wrapping the cooler with strapping tape at two locations. Finally, two signed and dated custody seals were placed over the cooler opening. All samples were hand-delivered to the analytical laboratory by ES personnel.

### **3.5.2 Field Quality Control**

Quality control (QC) procedures identified in the SI work plan were followed to ensure that the analytical data from soil and water sampling were both accurate and reproducible. A sampling event is considered to begin at the time sampling personnel arrived at the site and to end when these personnel have been gone for more than 24 hours. Analytical results for the primary samples, duplicates, and blanks are reported in Appendix E. Field QC samples for Nebraska ANGB consisted of trip and source-water blanks, equipment rinseates, field blanks, and coded field duplicates. The following information defines and explains the rinseates, blanks, and duplicates, as well as chain-of-custody procedures.

#### **3.5.2.1 Trip Blanks**

A trip blank is defined as a sample bottle filled with analyte-free laboratory reagent-grade water, transported to the sampling site, handled as a sample but not opened, and returned to the laboratory for analysis. These blanks are analyzed for volatile organic compounds only and serve to detect potential sample cross-contamination during shipment and handling.

During the sampling activities at Nebraska ANGB, four trip blanks were submitted for volatile organics analysis by U.S. Environmental Protection Agency (EPA) Method 624-CLPM. Analytical results, presented in Section 4 and Appendix E, show that all target compounds were reported at concentrations below the detection limits for all trip blanks analyzed.

#### **3.5.2.2 Field Blanks**

Field blanks consist of analyte-free laboratory reagent-grade water poured into appropriate sample containers at the sampling site, and returned to the laboratory for analysis. They are analyzed for all parameters of interest and are used to detect the potential contamination of samples during collection activities.

One field blank sample was collected at Nebraska ANGB during sampling activities. The analytical results for this sample, summarized in Appendix D, indicate there was no contamination of samples during collection.

#### **3.5.2.3 Source Water Blanks**

A source water blank is defined as a sample of water used during the installation and development of wells or as final decontamination rinse water. This includes potable water, well water, or high-pressure-liquid-chromatography- (HPLC) grade water. They are analyzed for all parameters of interest and detect the possible sample contamination due to the use of this source water during sampling.

One source water sample was collected during sampling activities at Nebraska ANGB. This sample was tap water collected on June 23, 1989. Approximately 10 gallons of tap water were added to well 6-MW1 during well construction to stabilize the borehole. The analytical results, presented in Appendix E, show slight amounts of trihalomethanes, metals, and anions. All parameters detected are very close to the quantifiable limits, and represent compounds commonly present in chlorinated potable water.

#### **3.5.2.4 Rinseate Samples**

Equipment rinseate samples are defined as analyte-free deionized water poured or pumped through the sampling device, transferred to the sample container, then transported to the laboratory for analysis. These samples serve to detect the potential sample contamination introduced as a result of improper or incomplete decontamination procedures. Analytical parameters for the rinseate samples include all laboratory measurements for the field samples collected in association with them.

Included in Appendix E is a summary of analytical results for the three rinseate samples collected at Nebraska ANGB. Methylene chloride (dichloromethane) was detected in the rinseate sample collected on 23 June 1989. This compound was not detected in the associated laboratory blank for the sample set. The methylene chloride was shown by process of elimination to be introduced to the rinseate sample as a bottle or source water contaminant and was demonstrated to be an isolated incident which did not compromise the quality of environmental sample data.



In addition to the rinseate samples described above, a sample of tap water from Building 631 was collected and analyzed. The tap water, supplied by the City of Lincoln through the municipal water supply system, was used in steam cleaning drilling equipment. Tap water was also added to well 6-MW1 immediately prior to well construction to aid in stabilization of the borehole. The sample contained small concentrations of the metals arsenic (0.004 mg/L), barium (0.110 mg/L), and selenium (0.003 mg/L). The common anions fluoride, chloride, nitrate, and sulfate were also detected at concentrations of 0.70 mg/L, 16.1 mg/L, 2.3 mg/L, and 94.3 mg/L, respectively. Comparison of the tap water quality with ground water sampling results from well 6-MW1 and upgradient wells 0206 and 2-MW1 do not indicate any bias from the addition of tap water.

#### **3.5.2.5 Coded Field Duplicate Samples**

Coded field duplicates are defined as two samples collected at a sampling location during a single act of sampling and coded in such a manner as to make them indistinguishable from other samples. These samples are used to assess the representativeness of the sampling procedures. Four coded field duplicate samples were collected in association with field sampling at Nebraska ANGB. The analytical results for the actual and coded field duplicates, along with the mean and the relative percent difference (RPD) are presented in Appendix D.

The numeric values of the RPD are small in most instances. Several samples show the presence of one or more analytes while the same analytes are missing in the coded field duplicate, or vice versa. In most cases, the analytes are within acceptable RPD ranges. Exceptions occur with soil or sediment-matrix samples, in which case the larger RPD values are attributed to the heterogeneous nature of these samples.

#### **3.5.3 Chain-of-Custody Procedures**

Sample custody procedures described here were followed throughout sample collection at Nebraska ANGB. Samples transported to the laboratory were placed in shipping containers (coolers) and sealed with custody seals. Two seals were placed on each cooler. Clear tape was placed over the seals to ensure that seals were not accidentally broken during shipment. A chain-of-custody record accompanied all samples to document the transfer of sample custody from the sampling team, to other ES team members and to the laboratory. Documentation included the signatures of the relinquishing and receiving individuals, and the date and time of custody transfer. Each shipment of samples to the laboratory was accompanied by the original chain-of-custody record which identified shipment contents. Copies of shipped chain-of-custody records were maintained by the ES Field Team Leader. Copies of the chain-of-custody forms are included in Appendix D.

#### **3.5.4 Field Equipment Calibration**

Field equipment which required daily calibration included the pH and EC meters. Orion® Models 201 and 211 pH meters were calibrated daily with 4.0 and 7.0, or 7.0 and 10.0 buffer-standards. EC was measured with a YSI® Model 33 EC

meter. Measurements of a standard EC solution (1,000  $\mu\text{mhos/cm}$ ) were recorded daily to determine the accuracy of the EC meter.

### **3.5.5 Laboratory Quality Control**

Laboratory QC data consists of the results obtained from the analysis of laboratory blanks, spiked samples, and laboratory duplicate samples. Laboratory-blank analyses are used to monitor the introduction of artifacts into the analysis process. Documenting that laboratory sample holding times are within time frames specified for each method is another function of laboratory QC.

#### **3.5.5.1 Holding Times**

All analyses requested were analyzed within the method specified holding times with the exception of the nitrite and nitrate anions. These are summarized in Appendix E. Technical holding times calculated from the date of sample collection to extraction, digestion and analysis was measured against criteria established under 40 CFR 136 (Clean Water Act) and EPA laboratory data validation functional guidelines (U.S. Environmental Protection Agency Data Review Work Group, 1988a and 1988b).

#### **3.5.5.2 Metals Analysis QC**

RPD and percentage recovery (PR) calculations were used to assess the reliability of laboratory analysis of metals. An RPD of less than 20 percent is normally used as a guide for precision assessment for duplicate analyses on water samples containing analyte concentrations greater than five times the method detection limit. An RPD of less than 50 percent is used for soil and sediment samples with the same concentrations of analyte. The uncertainty of detection is much greater at lower concentration levels. Thus the analyte concentration was considered in addition to the RPD value in determining the acceptability of a test's analytical precision. The heterogeneous nature of soil and sediment samples was also considered in evaluation of precision for these matrices. All sample analyses for metals met the precision criteria.

Accuracy of analytical results is measured as the PR of a laboratory spiked sample. For analyte concentrations within quantitative range, a PR range of 75 to 125 percent for water samples and a range of 50 to 150 percent for soils and sediments were considered acceptable. Larger deviations from 100 percent should be expected for samples for which the unspiked analysis result is near or below the quantitative limit. Heterogeneity of soil and sediment samples also affects the PR. Thus, the sample type and ambient analyte concentration were considered in addition to the PR in determining the acceptability of analytical accuracy for the test. All analyses met the advisory limits for accuracy.

#### **3.5.5.3 Anions and Total Recoverable Petroleum Hydrocarbons QC**

In evaluating common anions, advisory limits of 20 RPD for assessing precision, and 75 to 125 PR for assessing accuracy, were employed. Again, the heterogeneous nature of soil and sediment samples and the uncertainty of quantitation at low levels were taken into consideration during the assessment of both precision and accuracy.

All analyses for these parameters with the exception of fluoride met the advisory limits for both precision and accuracy. Nitrite results were validated as unusable and nitrate results were validated as estimated values because of excessive holding time violation.

#### **3.5.5.4 QC Results for Gas Chromatograph/Mass Spectrometer (GC/MS) Analyses**

Each method of organics analysis using the GC/MS, has specific precision and recovery criteria. The limitations are set at five times the method detection limit, unless otherwise specified. All samples met the method-specific precision and accuracy criteria.

#### **3.5.5.5 Laboratory Blanks**

In all cases, laboratory blank analysis results were below allowable detection limits for all parameters except methylene chloride (dichloromethane), which was not detected in any of the environmental samples with the exception of the isolated rinsewater blank which has been previously discussed.

#### **3.5.5.6 Accuracy**

The accuracy criteria for the data were met with the exception of the analytes that are flagged as estimated or unusable quantifications. Therefore, the data are acceptable with regard to accuracy noting the exceptions listed.

#### **3.5.5.7 Precision**

Precision results met the required limits, except where indicated by data validation flags. Therefore the data are acceptable within validation criteria limits with regard to precision.

#### **3.5.5.8 Representativeness**

All samples collected at Nebraska ANGB were collected under an approved work plan dictating acceptable field and analytical methods. The analyses results for laboratory blanks, coded field duplicates, source water blanks, and equipment rinsewaters further assure the representativeness of the analytical samples. All data collected indicate the samples analyzed are representative of actual field conditions except in the case of methylene chloride, as previously discussed.

#### **3.5.5.9 Completeness**

All samples collected were analyzed within allowable method-specified holding time requirements with the exception of nitrite and nitrate anions. The data obtained from all samples have been reviewed and determined to be acceptable and valid except where documented in the data validation summary report (Appendix D9).

## **SECTION 4**

### **INVESTIGATIVE FINDINGS**

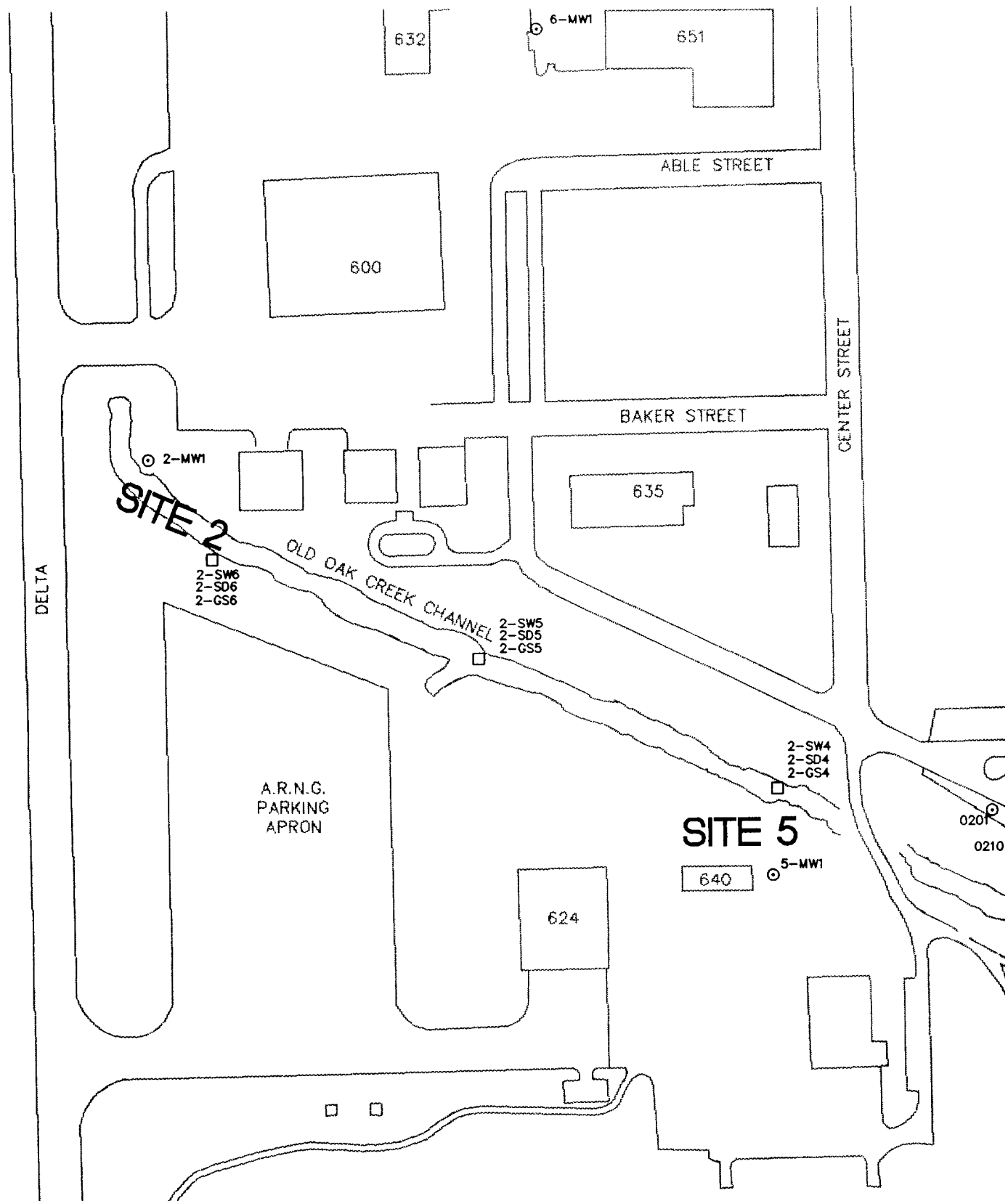
Facility geology and hydrogeology, ground water quality, surface water quality, stream sediment quality, and soil quality are summarized in this section based on the results of the field efforts described in Section 3. To evaluate how contaminants might migrate from different sites to potential receptors, it is necessary to establish an understanding of the local geology and hydrogeology. Therefore, a description of the geology and hydrogeology at the facility is presented in Section 4.1. This discussion is based on data collected during this and previous investigations. Field analytical results for ground water and surface water are discussed in Section 4.2, and laboratory analytical results for each of the six study sites shown in Figure 4.1 are presented in Sections 4.3 through 4.8.

#### **4.1 FACILITY GEOLOGY AND HYDROGEOLOGY**

Three generalized hydrogeologic cross sections were constructed across the study area to illustrate subsurface conditions. The cross section locations are shown in Figure 4.2, and the individual cross sections are shown in Figures 4.3 and 4.4. Cross sections A-A' and C-C' generally trend northwest to southeast, and cross section B-B' trends north to south. The potentiometric surface and extent of free product illustrated in these cross sections were developed from field data collected during June 1989.

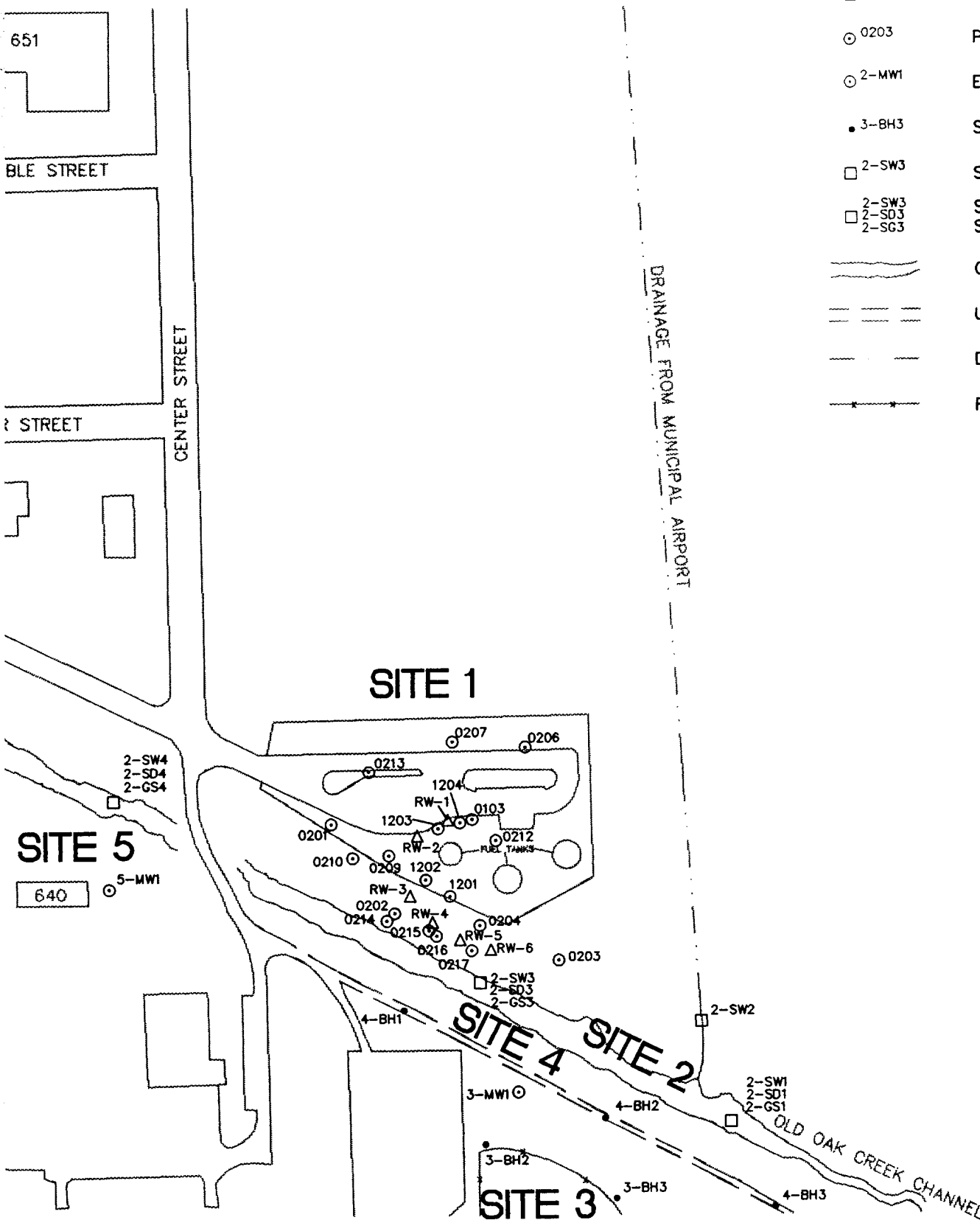
The unconsolidated deposits which mantle the bedrock at Nebraska ANGB consist predominantly of approximately 10 to 22 feet of fine-grained eolian silt and clay overlying variably-sorted fluvial sand and silty sand containing trace amounts of gravel. The borings drilled during the SI and previous investigations did not fully penetrate the fluvial sand, therefore the thickness of this unit at the study area was not determined, and the alluvium/bedrock contact is not shown on the cross sections. As shown on the cross sections, both upper, fine-grained and lower, coarse-grained units appear to be fairly continuous across the study area, with the upper unit increasing in thickness towards the southeast. Drilling records at Sites 1, 2, 3, and 5, including those contained in the Hazardous Materials Technical Center study (1987), indicate that the top of the saturated zone at these sites occurs either in the less-permeable silty clay and clay deposits or is approximately coincident with the top of the underlying sand (Figures 4.3 and 4.4). Depths to the top of the saturated zone in borings drilled at the facility ranged from 9 to 18 feet. Water levels in completed monitoring wells at these sites were 1 to 10 feet higher (an average of 3 feet higher) than the depth at which the saturated zone was

# SITE 6



# LEGEND

|                           |                                                      |
|---------------------------|------------------------------------------------------|
| △ RW-6                    | PRE-EXISTING RECOVERY                                |
| ○ 0203                    | PRE-EXISTING MONITOR WELL                            |
| ○ 2-MW1                   | NEW MONITOR WELL INSTALLATION                        |
| ● 3-BH3                   | SOIL BORING                                          |
| □ 2-SW3                   | SURFACE WATER SAMPLING POINT                         |
| □ 2-SW3<br>2-SD3<br>2-SG3 | SURFACE WATER SAMPLING, SAMPLING, AND GAGING STATION |
|                           | OLD OAK CREEK CHANNEL                                |
|                           | UNIMPROVED ROAD                                      |
|                           | DRAINAGE CULVERT                                     |
|                           | FENCE                                                |



0 1/2


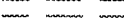
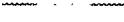

SI

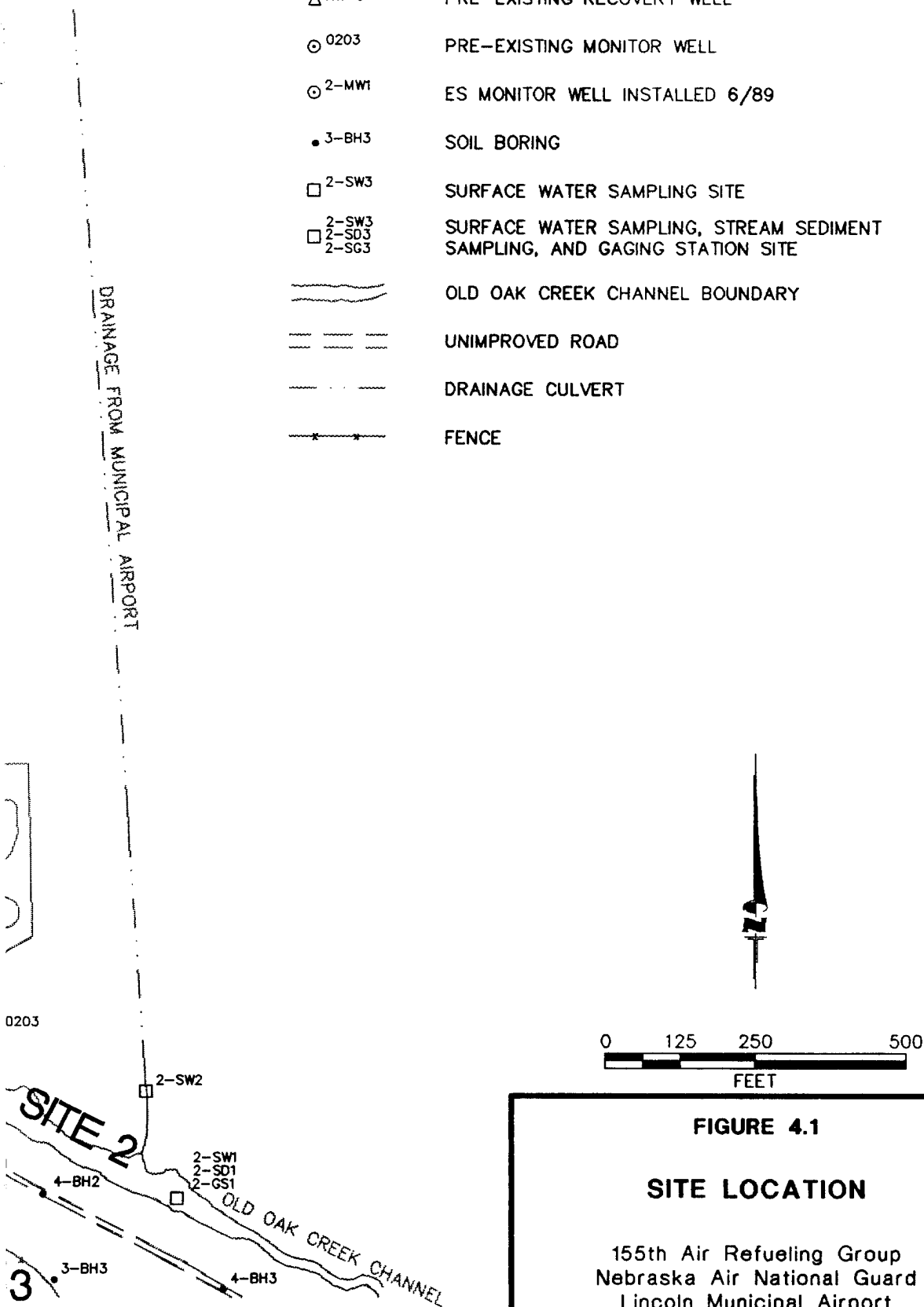
155th  
Nebraska  
Lincoln  
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**PARSONS ENGINEERING**

D

## LEGEND

|                                                                                   |                                                                              |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------|
| △ RW-6                                                                            | PRE-EXISTING RECOVERY WELL                                                   |
| ⊙ 0203                                                                            | PRE-EXISTING MONITOR WELL                                                    |
| ⊙ 2-MW1                                                                           | ES MONITOR WELL INSTALLED 6/89                                               |
| ● 3-BH3                                                                           | SOIL BORING                                                                  |
| □ 2-SW3                                                                           | SURFACE WATER SAMPLING SITE                                                  |
| □ 2-SW3<br>2-SO3<br>2-SG3                                                         | SURFACE WATER SAMPLING, STREAM SEDIMENT<br>SAMPLING, AND GAGING STATION SITE |
|  | OLD OAK CREEK CHANNEL BOUNDARY                                               |
|  | UNIMPROVED ROAD                                                              |
|  | DRAINAGE CULVERT                                                             |
|  | FENCE                                                                        |



**FIGURE 4.1**

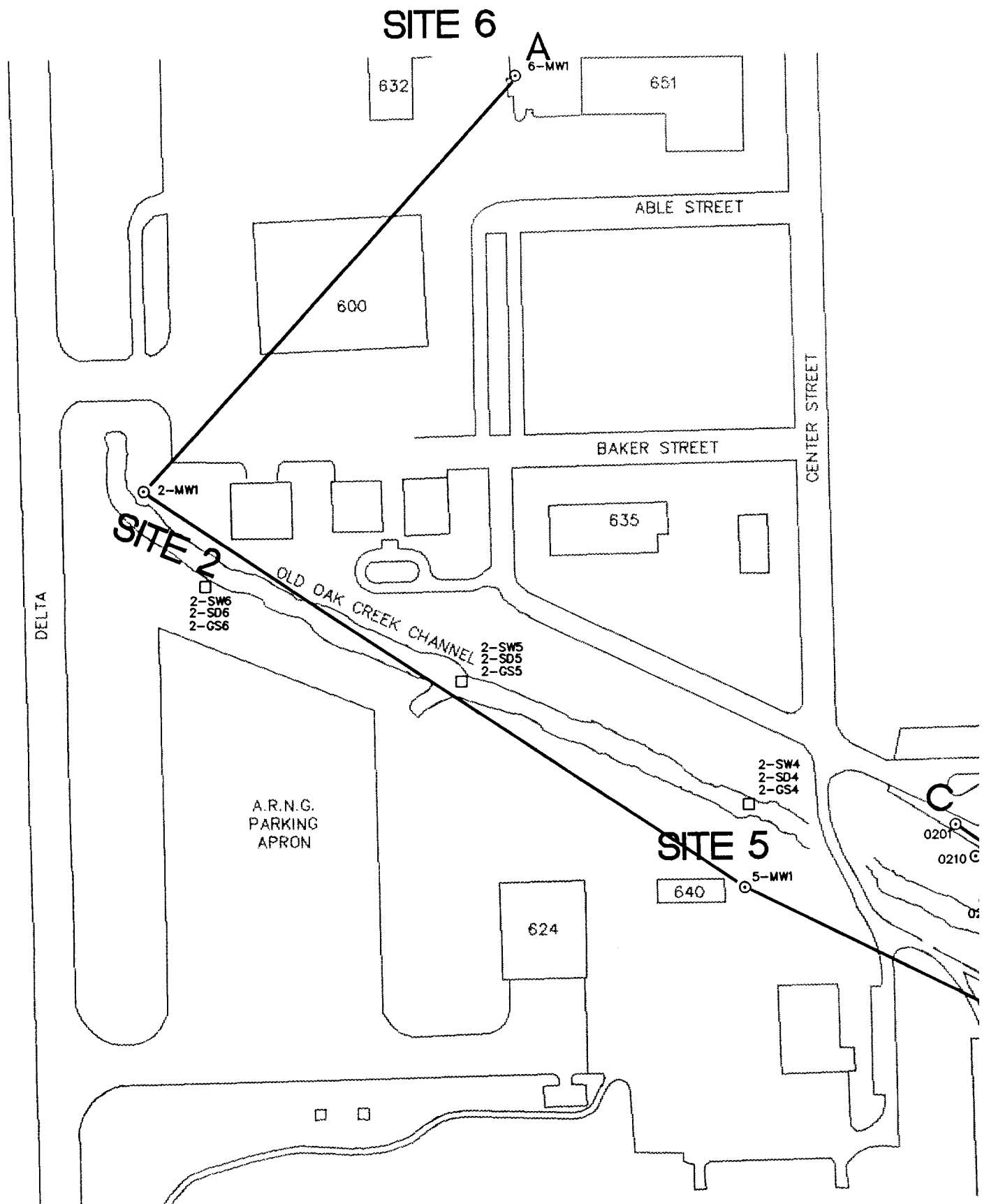
### SITE LOCATION

155th Air Refueling Group  
Nebraska Air National Guard  
Lincoln Municipal Airport  
Lincoln, Nebraska



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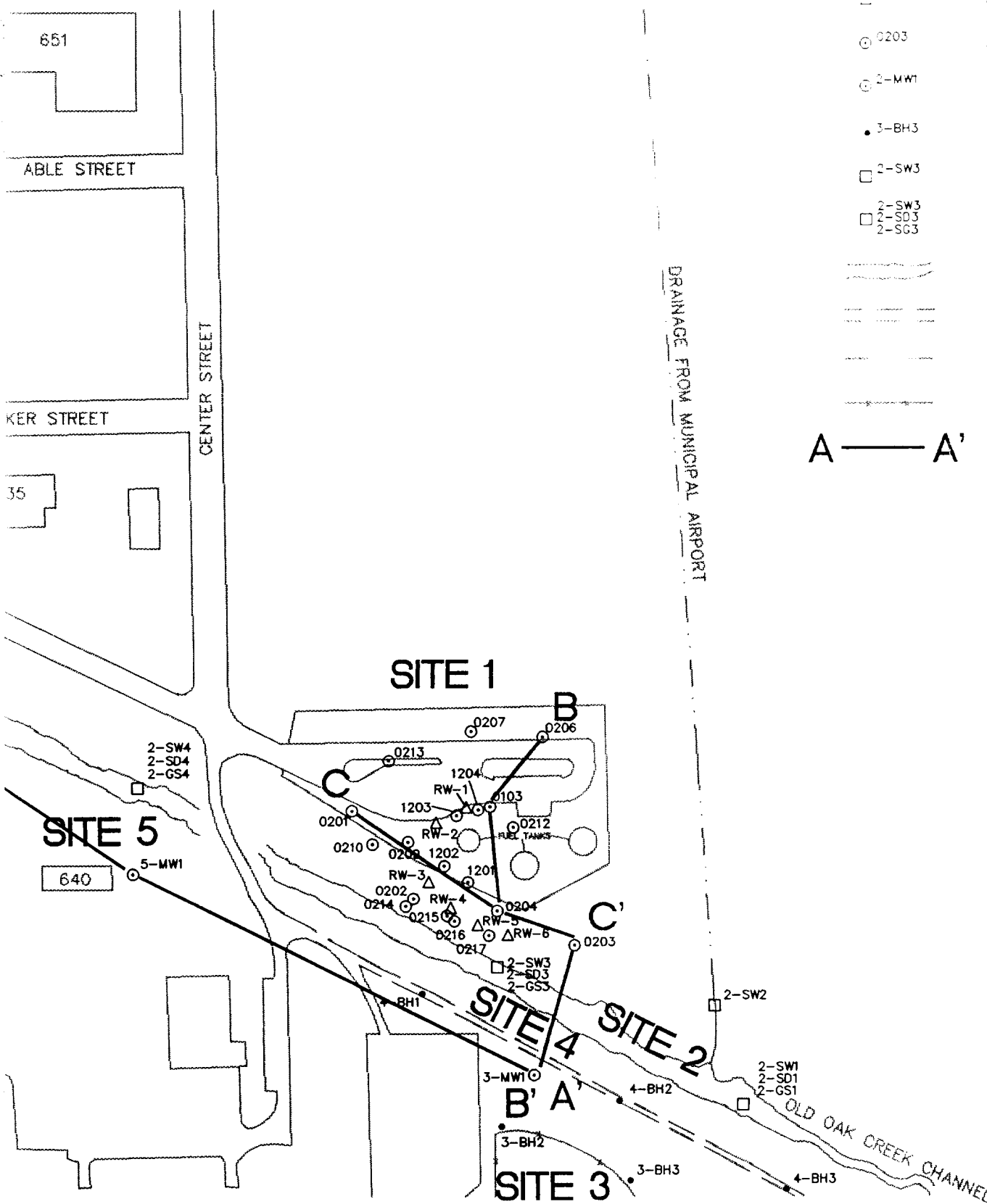
Denver, Colorado





# LEGEND

- PRE-EXISTING RECOVERY WELL
- PRE-EXISTING MONITORING WELL
- MONITORING WELL INSTALLATION
- SOIL BORING
- SURFACE WATER SAMPLING
- SURFACE WATER SAMPLING, AND GAGING
- OLD OAK CREEK CHANNEL
- UNIMPROVED ROAD
- DRAINAGE CULVERT
- FENCE
- CROSS SECTION LOCATION



HYDROGE

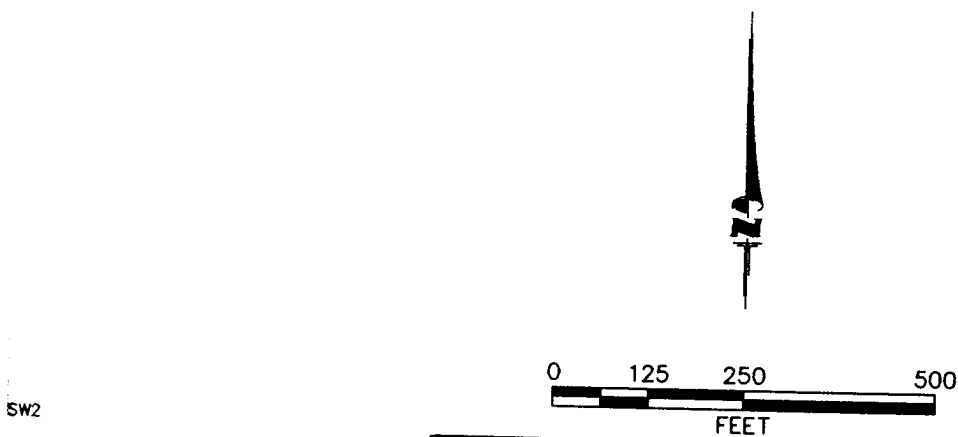
1551  
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# LEGEND

- △ RW-6 PRE-EXISTING RECOVERY WELL
- 0203 PRE-EXISTING MONITOR WELL
- 2-MW1 ES MONITOR WELL INSTALLED 6/89
- 3-BH3 SOIL BORING
- 2-SW3 SURFACE WATER SAMPLING SITE
- 2-SW3  
2-SD3  
2-SG3 SURFACE WATER SAMPLING, STREAM SEDIMENT  
SAMPLING, AND GAGING STATION SITE
- ~~~~~ OLD OAK CREEK CHANNEL BOUNDARY
- UNIMPROVED ROAD
- - - DRAINAGE CULVERT
- \* - \* - FENCE

A — A' CROSS SECTION LOCATION



**FIGURE 4.2**  
**HYDROGEOLOGIC CROSS SECTION**  
**LOCATION MAP**

155th Air Refueling Group  
Nebraska Air National Guard  
Lincoln Municipal Airport  
Lincoln, Nebraska

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Denver, Colorado



SITE 2 ————— SITE 3 ————

5-MWI

3-MWI

OLD OAK CREEK  
CHANNEL

A'  
SE

1165

1155

1145

1135

1125

ELEVATION (FEET, MSL)

VERTICAL EXAGGERATION = 40X

0 400 ft.  
HOR. SCALE

3-MWI

0206

0103

0103

0103

0103

0103

0103

0103

0103

0103

0103

0103

0103

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0103

0103

0103

SITE 1 ————— SITE 2 ———— SITE 3 ————

0204

0203

3-MWI

OLD OAK CREEK  
CHANNEL

B'  
SOUTH

1155

1145

1135

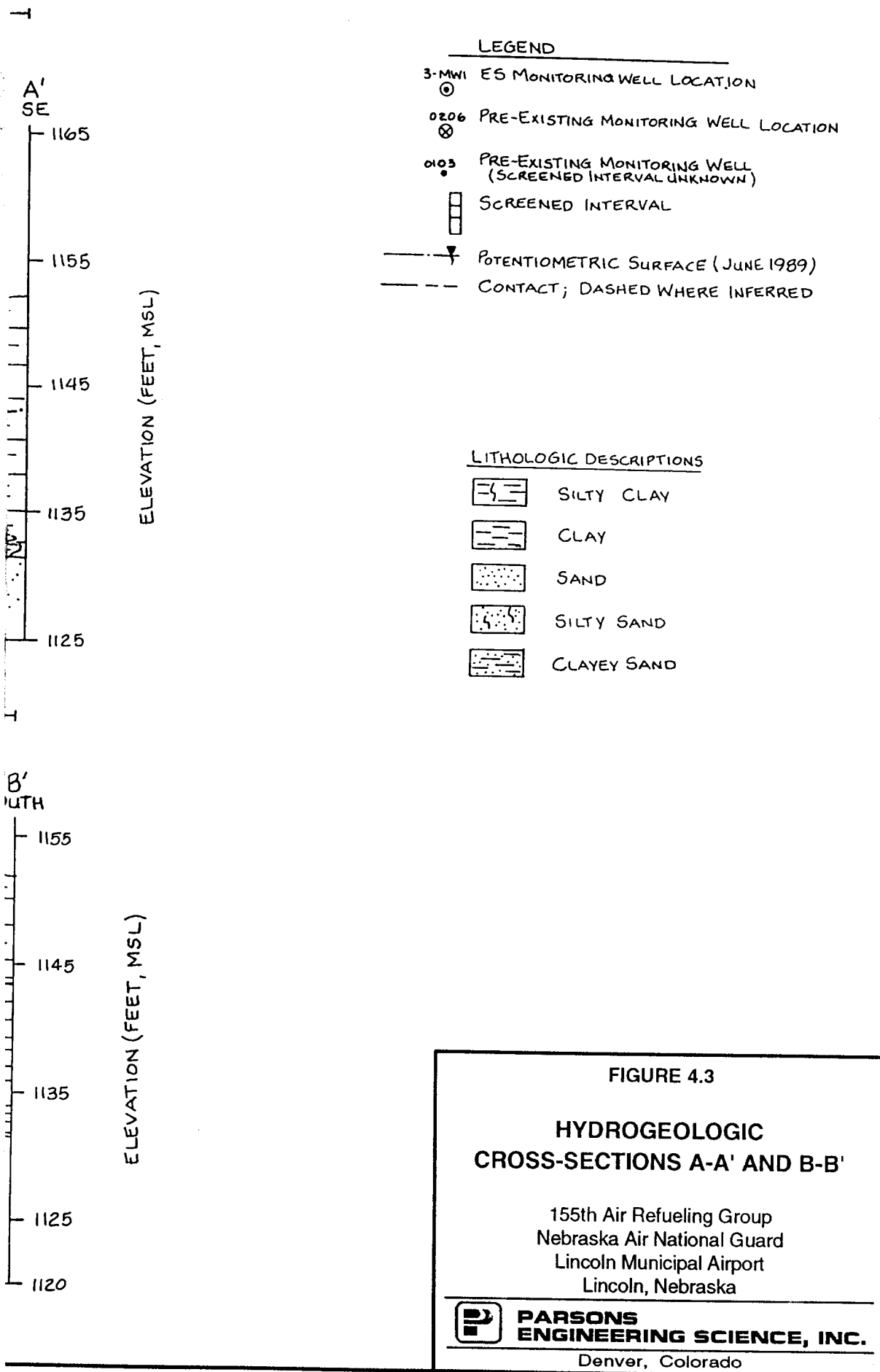
1125

1120

ELEVATION (FEET, MSL)

VERTICAL EXAGGERATION = 10X

0 100 ft.  
HOR. SCALE



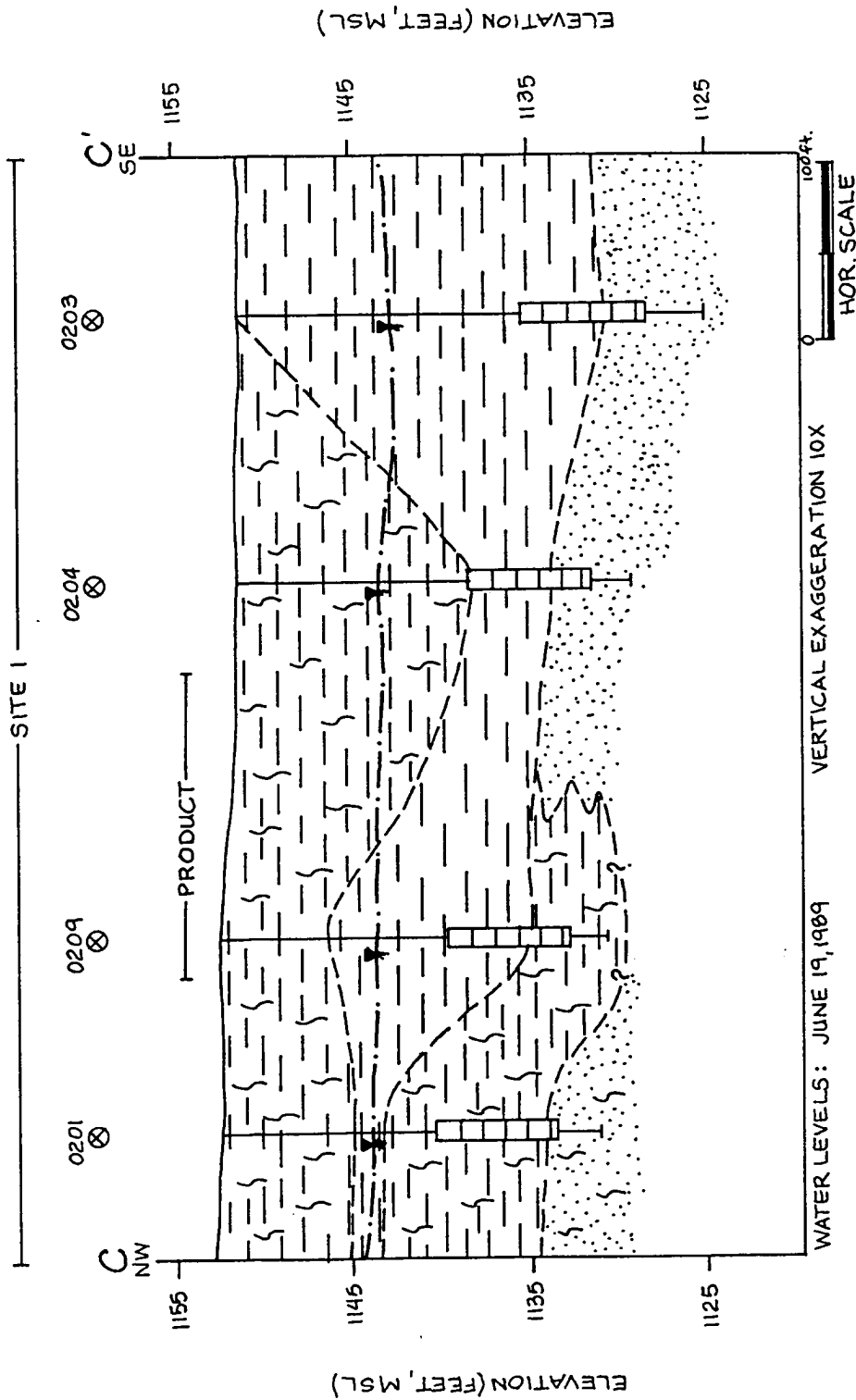


FIGURE 4.4

# HYDROGEOLOGIC CROSS SECTION C-C' SITE 1

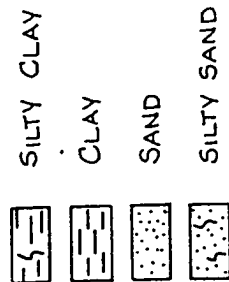
155th Air Refueling Group  
Nebraska Air National Guard  
Lincoln Municipal Airport  
Lincoln, Nebraska



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Denver, Colorado

## LITHOLOGIC DESCRIPTIONS



## LEGEND

- 0206 PRE-EXISTING MONITORING WELL
- ⊗ LOCATION
- SCREENED INTERVAL
- POTENTIOMETRIC SURFACE (JUNE 1989)
- CONTACT, DASHED WHERE INFERRED
- PRODUCT- EXTENT OF PRODUCT

encountered during drilling, indicating that ground water in the unconsolidated aquifer is semi-confined. At Site 6 the top of the saturated zone appeared to be below the top of the sand, suggesting that in this area the aquifer is locally unconfined. The saturated thickness of the unconsolidated aquifer at Nebraska ANGB exceeds 15 feet.

A potentiometric surface and stream elevation map (Figure 4.5) was constructed using June 1989 water level data. The ground water level data are summarized in Table 4.1, and stream elevation data are contained in Appendix C. Wells RW-2 and 1201, which contained measurable free product, were not used to construct this map. The distribution of potentiometric surface contours indicates that the direction of ground water flow is toward the southeast, although a local southerly component exists near Site 1. There appears to be a ground water divide in the center of Site 1 near recovery wells RW-2 and RW-3. West of these wells the general flow direction is southwesterly. East of these wells the general flow direction is to the southeast. The hydraulic gradient ranges from 0.001 feet per foot (ft/ft) measured between wells 2-MW1 and 5-MW1, to 0.004 ft/ft measured between wells 1203 and 0204.

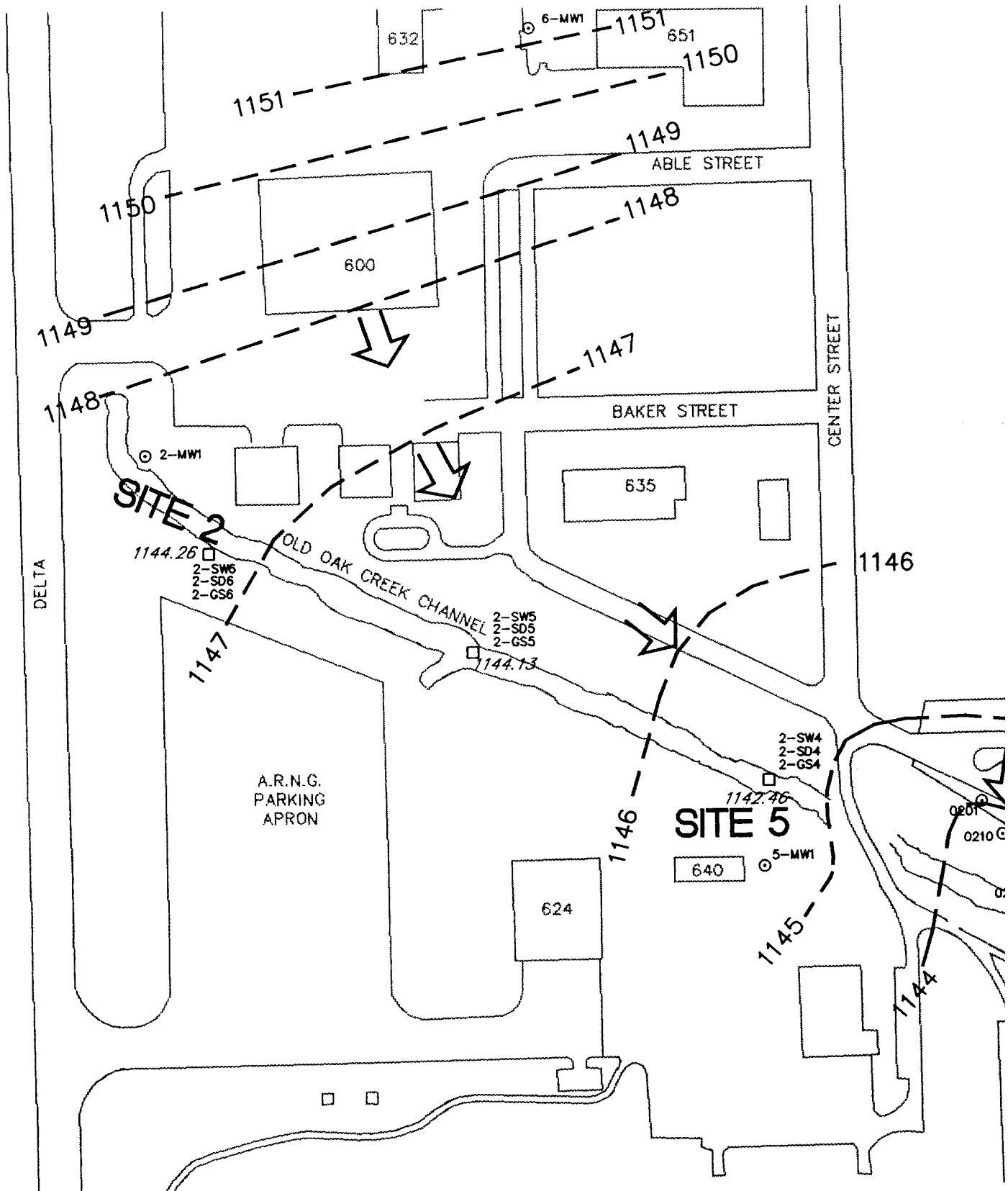
As shown in Figure 4.5, surface water elevations in the Old Oak Creek channel in June 1989 were generally 2 to 3 feet lower than estimated potentiometric surface elevations in the vicinity of the creek, suggesting that ground water may have been discharging to the creek. In addition, stream chemistry data, discussed in Section 4.3.1, suggest that some discharge of ground water to the creek was occurring at Site 1. The nature of the interaction between the creek and ground water may be seasonally variable.

The hydraulic conductivity of the clayey and sandy units encountered may be on the order of  $10^{-8}$  to  $10^{-4}$  centimeters per second (cm/s) and  $10^{-4}$  to  $10^{-2}$  cm/s, respectively (Freeze and Cherry, 1979). Average values for effective porosity are estimated to be 0.05 for the clayey unit and 0.25 for the sandy unit (Johnson, 1967). Based on these values, the average linear velocity of ground water movement beneath the facility in the clayey unit may range up to 8 feet per year (ft/yr). In contrast, ground water flow velocities in the sandy unit may range from 2 ft/yr to in excess of 150 ft/yr. Observations of monitoring well recharge rates during well development and purging indicate that the lower, sandy unit tends to be moderately to very permeable, while the upper, clayey unit has a low to moderate permeability.

## **4.2 GROUND WATER AND SURFACE WATER FIELD MEASUREMENTS**

Ground water field measurements of EC, pH, and temperature were obtained at the time of sampling. Measured values are listed in Tables 4.2 (ground water) and 4.3 (surface water). EC values for ground water and surface water ranged from 471 to 1789  $\mu\text{mhos/cm}$  and 534 to 1107  $\mu\text{mhos/cm}$ , respectively. The highest surface water conductivity value was obtained from the culvert draining the municipal airport (station SW2), while ground water values tended to be higher at Site 1. Ground water pH values ranged from 5.75 to 8.30, while surface water pH values of 7.25 to 10.55 were obtained. The most alkaline pH values were obtained in the Old

# SITE 6





# LEGEND

△ RW-6 PRE-EXISTING RECO

○ 0203 PRE-EXISTING MONI

○ 2-MW1 ES MONITOR WELL

● 3-BH3 SOIL BORING

□ 2-SW3 SURFACE WATER S

1140.40 □ 2-SW3  
2-SD3  
2-SG3 SURFACE WATER S  
SAMPLING, AND GA  
WITH STREAM SURF  
ABOVE MEAN SEA

~~~~~ OLD OAK CREEK CH

--- UNIMPROVED ROAD

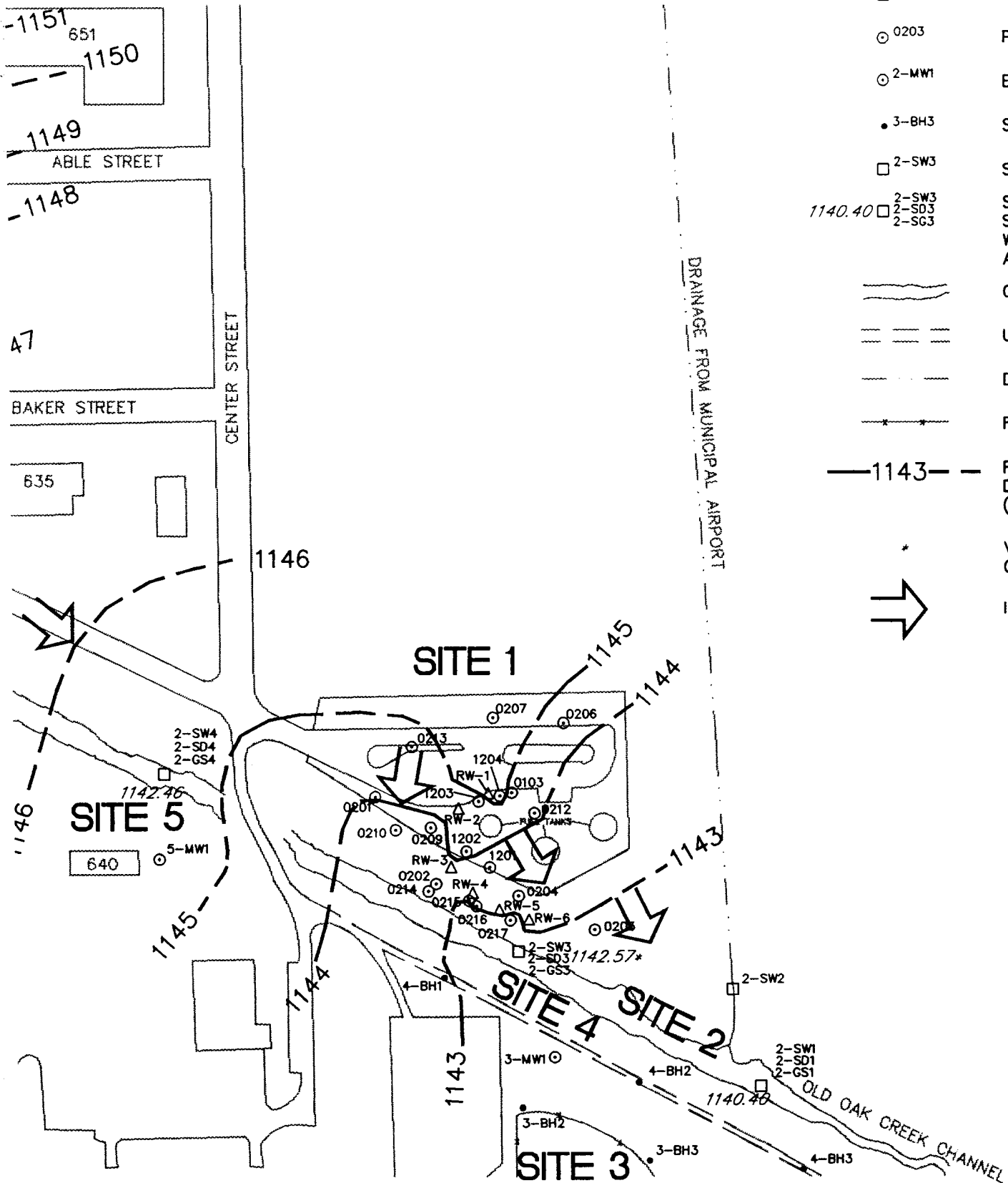
- - - DRAINAGE CULVERT

- * - FENCE

— 1143 — POTENTIOMETRIC SU
DASHED WHERE INF
(FEET ABOVE MEAN

VALUE QUESTIONAE
OF STREAM GAGE







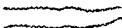
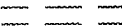
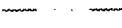
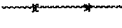
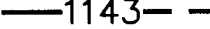


INFERRED GROUND



POT
AND S

1
Ne

LEGEND

- | | | |
|---|-------------------------|--|
|  | RW-6 | PRE-EXISTING RECOVERY WELL |
|  | 0203 | PRE-EXISTING MONITOR WELL |
|  | 2-MW1 | ES MONITOR WELL INSTALLED 6/89 |
|  | 3-BH3 | SOIL BORING |
|  | 2-SW3 | SURFACE WATER SAMPLING SITE |
|  | 2-SW3
2-SD3
2-SG3 | SURFACE WATER SAMPLING, STREAM SEDIMENT SAMPLING, AND GAGING STATION SITE WITH STREAM SURFACE ELEVATION IN FEET ABOVE MEAN SEA LEVEL |
|  | | OLD OAK CREEK CHANNEL BOUNDARY |
|  | | UNIMPROVED ROAD |
|  | | DRAINAGE CULVERT |
|  | | FENCE |
|  | 1143 | POTENTIOMETRIC SURFACE CONTOUR
DASHED WHERE INFERRED
(FEET ABOVE MEAN SEA LEVEL) |
|  | | VALUE QUESTIONABLE DUE TO RESETTING OF STREAM GAGE |
|  | | INFERRED GROUND WATER FLOW DIRECTION |

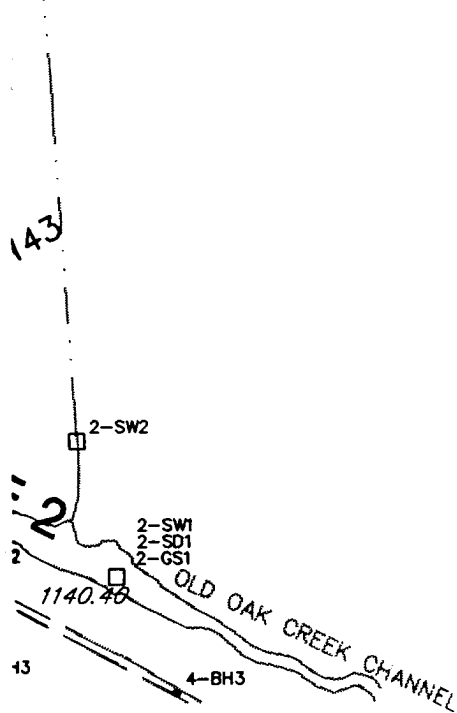


FIGURE 4.5
POTENTIOMETRIC SURFACE
AND STREAM ELEVATION MAP
JUNE 1989

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



**PARSONS
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Denver, Colorado

TABLE 4.1
WELL INSTALLATION AND WATER TABLE SUMMARY
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| WELL
NUMBER | TOTAL
DEPTH
(ft) | TOP OF PVC
ELEVATION
OF CASING
(ft. m.s.l.) a/ | DATE
MEASURED | DEPTH TO | | CASING
HEIGHT
(ft) | WATER LEVEL
ELEVATION
(ft. m.s.l.) | PRODUCT
OBSERVATION |
|----------------|------------------------|---|------------------|---------------------------|--|--------------------------|--|--------------------------------|
| | | | | WATER
LEVEL b/
(ft) | | | | |
| INSTALLED 6/89 | | | | | | | | |
| 2-MW1 | 23.0 | 1158.11 | 06/26/89 | 10.88 | | -0.28 | 1147.23 | None |
| 3-MW1 | 21.7 | 1152.05 | 06/26/89 | 8.85 | | -0.25 | 1143.20 | None |
| 5-MW1 | 20.0 | 1152.51 | 06/26/89 | 6.80 | | -0.25 | 1145.71 | None |
| 6-MW1 | 22.0 | 1162.75 | 06/26/89 | 11.65 | | -0.35 | 1151.10 | None |
| INSTALLED 2/83 | | | | | | | | |
| (SITE 1) | | | | | | | | |
| 0103 | 14.5 | 1152.59 | 06/19/89 | 8.33 | | 0 | 1144.26 | None |
| 0201 | 14.7 | 1152.50 | 06/19/89 | 8.46 | | 0 | 1144.04 | Fuel odor |
| 0202 | 16.3 | 1151.96 | 06/19/89 | 8.86 | | 0 | 1143.10 | None |
| 0203 | 26.0 | 1151.40 | 06/19/89 | 8.81 | | 0 | 1142.59 | Dry |
| 0204 | NA ^{c/} | 1151.48 | 06/19/89 | 7.78 | | 0 | 1143.70 | None |
| 0206 | 12.5 | 1150.93 | 06/19/89 | 6.70 | | 0 | 1144.23 | None |
| 0207 | NA | 1150.73 | 06/19/89 | 4.86 | | 0 | NA | None |
| 0209 | 21.5 | 1152.43 | 06/19/89 | 8.60 | | 0 | 1143.83 | Slight sheen; strong fuel odor |
| 0210 | 16.2 | 1152.05 | 06/19/89 | 8.19 | | 0 | 1143.86 | None |

TABLE 4.1 (Continued)
WELL INSTALLATION AND WATER TABLE SUMMARY
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| WELL
NUMBER | TOTAL
DEPTH
(ft) | TOP OF PVC
ELEVATION
OF CASING
(ft. m.s.l.) a/ | DEPTH TO | | CASING
HEIGHT
(ft) | WATER LEVEL
ELEVATION
(ft. m.s.l.) | PRODUCT
OBSERVATION |
|----------------|------------------------|---|------------------|---------------------------------|--------------------------|--|-------------------------------------|
| | | | DATE
MEASURED | WATER
LEVEL b/
LEVEL (ft) | | | |
| 0212 | NA | 1152.59 | 06/19/89 | 8.47 | 0 | 1144.12 | None |
| 0213 | NA | 1152.37 | 06/19/89 | 8.01 | 0 | 1144.36 | None |
| 0214 | 17.7 | 1151.65 | 06/19/89 | 8.24 | 0 | 1143.41 | None |
| 0215 | 11.5 | 1151.21 | 06/19/89 | 8.36 | 0 | 1142.85 | None |
| 0216 | 15.3 | 1151.27 | 06/19/89 | 8.07 | 0 | 1143.20 | Very slight sheen; slight fuel odor |
| 0217 | 16.0 | 1151.54 | 06/19/89 | 8.89 | 0 | 1142.65 | None |
| 1201 | 18.2 | 1152.15 | 06/19/89 | 8.58 | 0 | 1143.57 | 0.25 ft. of product |
| 1202 | NA | 1151.97 | 06/19/89 | 7.07 | 0 | 1144.90 | Strong film |
| 1203 | NA | 1152.81 | 06/19/89 | 8.41 | 0 | 1144.40 | Fuel odor; slight film |
| 1204 | NA | 1152.33 | 06/19/89 | 1.79 | 0 | 1150.54 | None |
| RW-1 | NA | 1154.57 | 06/19/89 | 9.07 | 0 | 1145.50 | None |
| RW-2 | NA | 1154.57 | 06/19/89 | 10.92 | 0 | 1143.65 | 1.07 ft. of product |
| RW-3 | NA | 1154.34 | 06/19/89 | 10.53 | 0 | 1143.81 | None |
| RW-4 | NA | 1154.70 | 06/19/89 | 11.02 | 0 | 1143.68 | None |
| RW-5 | NA | 1154.15 | 06/19/89 | 10.90 | 0 | 1143.25 | None |
| RW-6 | NA | 1154.30 | 06/19/89 | 10.79 | 0 | 1143.51 | None |

a/ ft. m.s.l. = Feet above mean sea level.

b/ Depth below top of PVC casing.

c/ NA = Not available.

TABLE 4.2

SUMMARY OF ANALYTICAL RESULTS OF GROUND WATER SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | ANALYTICAL RESULTS ^{a/} | | | | | | | | | |
|------|-----------------------------|-----------------|----------------------------------|-------------------|-------------------|----------------------|--------------|--------------------|--------------------|----------------------|-------------------|-------------------|
| | | | Volatile Organics | | | | | Total | | | Anions | |
| | | | BENZENE
Units (µg/L) | BENZENE
(µg/L) | TOLUENE
(µg/L) | XYLENES b/
(µg/L) | Hydrocarbons | FLUORIDE
(mg/L) | CHLORIDE
(mg/L) | NITRITE
(mg/L) | NITRATE
(mg/L) | SULFATE
(mg/L) |
| 1 | MW0204 | 06/24/89 | 5 U ^{d/} | 5 U | 5 U | 5 U | <1.0 | 0.51 J d/ | 45.6 | <0.1 R ^{d/} | 1.7 J | 30.8 |
| 1 | MW0206 | 06/22/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.54 J | 95.8 | <0.1 R | 8.7 J | 69.8 |
| 1 | MW0218 f/
Rinseate Blank | 06/22/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.55 J | 91.8 | <0.1 R | 8.6 J | 68.8 |
| 1 | Field Blank | 06/22/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | <0.05 J | <1.0 | <0.1 R | <0.1 J | <0.1 |
| 1 | MW0209 | 06/22/89 | 510 | 150 | 42 J | 800 | 39.6 | 1.03 J | 33.6 | <0.1 R | 0.3 J | 11.5 |
| 1 | MW0210 | 06/22/89 | 62 | 24 | 5 U | 140 | 1.8 | 0.58 J | 78.4 | <0.1 R | 19.2 J | 45.2 |
| 1 | MW0214 | 06/22/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.56 J | 74.8 | <0.1 R | 5.2 J | 63.8 |
| 1 | MW0216 | 06/22/89 | 14 | 5 U | 5 U | 10 | <1.0 | 0.57 J | 86.6 | <0.1 R | 11.2 J | 51.2 |
| 1 | MW1203 | 06/22/89 | 610 | 1100 | 130 U | 4600 | 91.4 | 0.35 J | 6.4 | <0.1 R | <0.1 J | 13 |
| 2 | MW1 | 06/23/89 | 5 U | 5 U | 5 U | 5 U | 1.8 | 0.52 J | 47.4 | <0.1 R | 18.2 J | 43.4 |
| 2 | Rinseate Blank | 06/23/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | <0.05 J | <0.1 | <0.1 R | <0.1 J | <0.1 |
| 3 | MW1 | 06/26/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.73 J | 100.4 | <0.1 R | 5.1 J | 62.0 |
| 5 | MW1 | 06/24/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 1.00 J | 32.0 | <0.1 R | 1.5 J | 58.6 |
| 5 | Rinseate Blank | 06/24/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | <0.05 J | <0.1 | <0.1 R | <0.1 J | <0.1 |
| 6 | MW1 | 06/23/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | NA ^{g/} | NA | NA | NA | NA |
| 6 | TAP h/ | 06/23/89 | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.70 J | 16.1 | <0.1 R | 2.3 J | 94.3 |

TABLE 4.2 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF GROUND WATER SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | ANALYTICAL RESULTS a/
Metals | | | | | | | |
|------|----------------|-----------------|---------------------------------|------------------|-------------------|--------------------|----------------|-------------------|--------------------|------------------|
| | | | ARSENIC
Units (mg/L) | BARIUM
(mg/L) | CADMIUM
(mg/L) | CHROMIUM
(mg/L) | LEAD
(mg/L) | MERCURY
(mg/L) | SELENIUM
(mg/L) | SILVER
(mg/L) |
| 1 | MW0204 | 06/24/89 | 0.013 J | 0.103 | 0.002 UJ i/ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 J | 0.002 UJ |
| 1 | MW0206 | 06/22/89 | 0.006 J | 0.335 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 J | 0.002 UJ |
| 1 | MW0218 i/ | 06/22/89 | 0.005 J | 0.346 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 1 | Rinseate Blank | 06/22/89 | 0.002 UJ | 0.008 UJ | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 1 | Field Blank | 06/22/89 | 0.002 UJ | 0.008 J | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 1 | MW0209 | 06/22/89 | 0.048 J | 0.220 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 1 | MW0210 | 06/22/89 | 0.007 J | 0.248 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.004 J | 0.002 UJ |
| 1 | MW0214 | 06/22/89 | 0.007 J | 0.139 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.017 J | 0.002 UJ |
| 1 | MW0216 | 06/22/89 | 0.004 J | 0.144 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 J | 0.002 UJ |
| 1 | MW1203 | 06/22/89 | 0.038 J | 0.428 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 2 | MW1 | 06/23/89 | 0.004 J | 0.197 | 0.002 UJ | 0.003 J | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 2 | Rinseate Blank | 06/23/89 | 0.002 UJ | 0.008 UJ | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 3 | MW1 | 06/26/89 | 0.004 J | 0.309 | 0.002 UJ | 0.005 J | 0.005 UJ | 0.0005 U | 0.010 J | 0.002 UJ |
| 5 | MW1 | 06/24/89 | 0.025 J | 0.465 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 5 | Rinseate Blank | 06/24/89 | 0.002 UJ | 0.008 UJ | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 6 | MW1 | 06/23/89 | 0.003 J | 0.197 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.002 UJ | 0.002 UJ |
| 6 | TAP h/ | 06/23/89 | 0.004 J | 0.110 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.0005 U | 0.003 J | 0.002 UJ |

TABLE 4.2 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF GROUND WATER SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | Units | FIELD OBSERVATIONS | | |
|------|----------------|-----------------|-------|----------------------------------|------|---------------------|
| | | | | CONDUCTIVITY
(μ mhos/cm) | pH | TEMPERATURE
(°C) |
| 1 | MW0204 | 06/24/89 | | 577 | 7.30 | 14.5 |
| 1 | MW0206 | 06/22/89 | | 960 | 7.65 | 13.5 |
| 1 | MW0218 e/ | 06/22/89 | | 960 | 7.65 | 13.5 |
| 1 | Rinseate Blank | 06/22/89 | | NA | NA | NA |
| 1 | Field Blank | 06/22/89 | | NA | NA | NA |
| 1 | MW0209 | 06/22/89 | | 1789 | 7.45 | 14.5 |
| 1 | MW0210 | 06/22/89 | | 1098 | 7.9 | 15.5 |
| 1 | MW0214 | 06/22/89 | | 1066 | 7.0 | 15 |
| 1 | MW0216 | 06/22/89 | | 1077 | 6.65 | 16 |
| 1 | MW1203 | 06/22/89 | | 471 | 6.85 | 15 |
| 2 | MW1 | 06/23/89 | | 936 | 8.30 | 13 |
| 2 | Rinseate Blank | 06/23/89 | | NA | NA | NA |
| 3 | MW1 | 06/26/89 | | — | 5.75 | 15 |
| 5 | MW1 | 06/24/89 | | 1626 | — | 14 |
| 5 | Rinseate Blank | 06/24/89 | | NA | NA | NA |
| 6 | MW1 | 06/23/89 | | 936 | 8.20 | 15 |
| 6 | TAP h/ | 06/23/89 | | NA | NA | NA |

a/ EPA Methods 624-CLPM, 625-CLPM, 418.1, SW3010/3020; 6010/7000, and SMA 429 were used for June, 1989 samples. Organics included in EPA analyses methods but not included in table were not detected at any site. See Appendix E for complete analytical results.

Units of measure: μ g/L = micrograms per liter; mg/L = milligrams per liter; μ mhos/cm = micromhos per centimeter; °C = degrees centigrade.

b/ Value reported is total of m+p+o Xylenes.

c/ U = Compound was analyzed for but not detected. Value presented is the sample quantitation limit.

d/ J = The numerical value represents a valid compound identification but is an estimated quantity because associated quality control criteria were not met.

e/ R = The value is an unusable quantity (compound may or may not be present) because associated quality control criteria were exceeded excessively.

f/ Duplicate of preceding sample.

g/ NA = Not analyzed.

h/ TAP = tap water blank.

i/ UI = The analyte was analyzed for but was not detected above the level of the associated value. The associated numerical value may not accurately or precisely represent the sample quantitation limit.

slightly murky;
brown, no odor

black+murky, fuel odor, sl.sheen
brown-gray, murky
suspended sed., brown, murky
suspended sed., gray, v.sl.
sheen; slight fuel odor
slight film on water surface
slight turbid, lt. brown

slightly turbid
clear

brown, slightly murky

TABLE 4.3

SUMMARY OF ANALYTICAL RESULTS OF SURFACE WATER SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE SAMPLED | Units | ANALYTICAL RESULTS ^{a/} | | | | | | | | | |
|------|-------------------|--------------|-------------------|----------------------------------|--------------------------------|--------------------------------|--|--|-------------------------------|-------------------------------|------------------------------|------------------------------|------------------------------|
| | | | | Volatile Organics | | | | Total | | | Anions | | |
| | | | | BENZENE
($\mu\text{g/L}$) | BENZENE
($\mu\text{g/L}$) | TOLUENE
($\mu\text{g/L}$) | XYLENES ^{b/}
($\mu\text{g/L}$) | Petroleum
Hydrocarbons
(mg/L) | FLUORIDE
(mg/L) | CHLORIDE
(mg/L) | NITRITE
(mg/L) | NITRATE
(mg/L) | SULFATE
(mg/L) |
| 2 | SW1 | 06/19/89 | 5 U ^{c/} | 5 U | 5 U | 5 U | 5 U | 1.6 | 0.74 J ^{d/} | 68.0 | <0.1 R ^{e/} | 0.1 J | 89.0 |
| 2 | SW2 | 06/19/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | 1.19 J | 175.5 | <0.1 R | <0.1 J | 137.2 |
| 2 | SW3 | 06/19/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.41 J | 21.7 | <0.1 R | <0.1 J | 18.0 |
| 2 | SW7 ^u | 06/19/89 | 5 U | 5 U | 5 U | 5 U | 5 U | 1.3 | 0.41 J | 20.6 | <0.1 R | <0.1 J | 18.1 |
| 2 | SW4 | 06/20/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.42 J | 25.9 | <0.1 R | 0.3 J | 45.4 |
| 2 | SW5 | 06/20/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.60 J | 36.8 | <0.1 R | 2.7 J | 158.8 |
| 2 | SW6 | 06/20/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | 0.49 J | 88.0 | <0.1 R | 2.4 J | 19.2 |
| 2 | SW8 ^{g/} | 06/20/89 | 5 U | 5 U | 5 U | 5 U | 5 U | <1.0 | NA ^{h/} | NA | NA | NA | NA |

TABLE 4.3 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF SURFACE WATER SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE SAMPLED | Units | ANALYTICAL RESULTS a/ | | | | | | | | FIELD OBSERVATIONS | | |
|------|-----------|--------------|-------|-----------------------|---------------|----------------|-----------------|-------------|----------------|-----------------|---------------|-------------------------|-------|------------------|
| | | | | Metals | | | | | | | | CONDUCTIVITY (μmhos/cm) | pH | TEMPERATURE (°C) |
| | | | | ARSENIC (mg/L) | BARIUM (mg/L) | CADMIUM (mg/L) | CHROMIUM (mg/L) | LEAD (mg/L) | MERCURY (mg/L) | SELENIUM (mg/L) | SILVER (mg/L) | | | |
| 2 | SW1 | 06/19/89 | | 0.008 J | 0.07 | 0.002 UJ i/ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.002 UJ | 0.002 UJ | 774 | 8.80 | 32.0 |
| 2 | SW2 | 06/19/89 | | 0.006 J | 0.06 J | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.005 J | 0.002 UJ | 1107 | 10.55 | 34.0 |
| 2 | SW3 | 06/19/89 | | 0.017 J | 0.03 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.005 J | 0.002 UJ | 534 | 9.60 | 30.5 |
| 2 | SW7 | 06/19/89 | | 0.014 J | 0.04 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.002 J | 0.002 UJ | 534 | 9.60 | 30.5 |
| 2 | SW4 | 06/20/89 | | 0.011 J | 0.08 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.002 UJ | 0.002 UJ | 742 | 7.35 | 22.0 |
| 2 | SW5 | 06/20/89 | | 0.006 J | 0.14 | 0.002 UJ | 0.002 UJ | 0.005 UJ | 0.005 U | 0.003 | | | | |

Oak Creek channel adjacent to and downstream of station SW3, and in the culvert from the municipal airport. Temperatures of ground water were relatively uniform, varying from 13 to 16 degrees centigrade (°C). Surface water temperatures ranged from 20 to 34°C, generally increasing in a downstream direction.

4.3 SITE 1 - PRODUCT OCCURRENCE AND GROUND WATER QUALITY RESULTS

4.3.1 Free-Product Plume Characterization

During the field program, observations of petroleum product in the monitoring and recovery wells at Site 1 were documented. Available geologic logs and well construction information for these wells, as well as geologic logs for soil borings which were not converted to monitoring wells, are contained in Appendix B. Based on these observations, an isocontour map of measured product thickness was constructed (Figure 4.6). Wells RW-2 and 1201 contained the only measurable product during June 1989. An apparent product thickness of 1.07 feet was observed in well RW-2, and 0.25 feet was observed in well 1201. In addition, product films were noted in wells 1202 and 1203, and slight sheens were present in wells 0209 and 0216.

Where present, petroleum product floating on the ground water appears to be migrating through the less-permeable clay and silty clay deposits. Free-floating product may migrate at approximately one-half to one-quarter the rate of ground water (Shepherd, 1983; Schwille, 1967). Therefore the average linear velocity of product towards the Old Oak Creek channel may range up to 4 ft/yr.

4.3.2 Ground Water Quality

Seven monitoring wells in Site 1 were sampled during the field investigation for volatile and semivolatile organics, total petroleum hydrocarbons (TPH), common anions, and dissolved metals. The location of each sampled well is illustrated in Figure 4.1. A summary of analytical results of ground water sampling is provided in Table 4.2, and a complete set of results is contained in Appendix E. Analytical results are compared to regulatory criteria in Section 5.

Volatile organic compounds were detected in wells 0209, 0210, 0216, and 1203. Compounds detected include benzene, ethyl benzene, toluene, and xylenes. The approximate distribution of dissolved volatile organic constituents in ground water at Site 1 is represented in Figure 4.7, which shows the concentration of benzene in ground water. The extent of dissolved contaminants in the ground water exceeds that of the free product. The highest concentrations of benzene were detected in wells 1203 and 0209, which are located near well RW-2, which contained 1.07 feet of free product in June 1989 (Figure 4.6). The benzene plume appears to extend to the south towards the Old Oak Creek channel, while the western extent of the plume is not well defined due to a lack of data points.

There were no semivolatile compounds detected in any of the wells sampled. Figure 4.8 illustrates the concentrations of TPH detected in Site 1 ground water. Petroleum hydrocarbons were detected in wells 0209, 0210, and 1203 at

LEGEND

- △ RW-2
1.07
- 1201
0.25
- 0.02 —
- ND —
- ND
- PRE-EXISTING RECOVERY WELL WITH OBSERVED PRODUCT THICKNESS (FEET)
- PRE-EXISTING MONITORING WELL WITH OBSERVED PRODUCT THICKNESS (FEET)
- INFERRED OUTLINE OF AREA WITH GREATER THAN 0.02 FEET FREE PRODUCT ON GROUND WATER SURFACE; DASHED WHERE INFERRED
- INFERRED OUTLINE OF AREA WITH SHEEN TO 0.02 FT. FREE PRODUCT ON GROUND WATER SURFACE; DASHED WHERE INFERRED
- NOT DETECTED

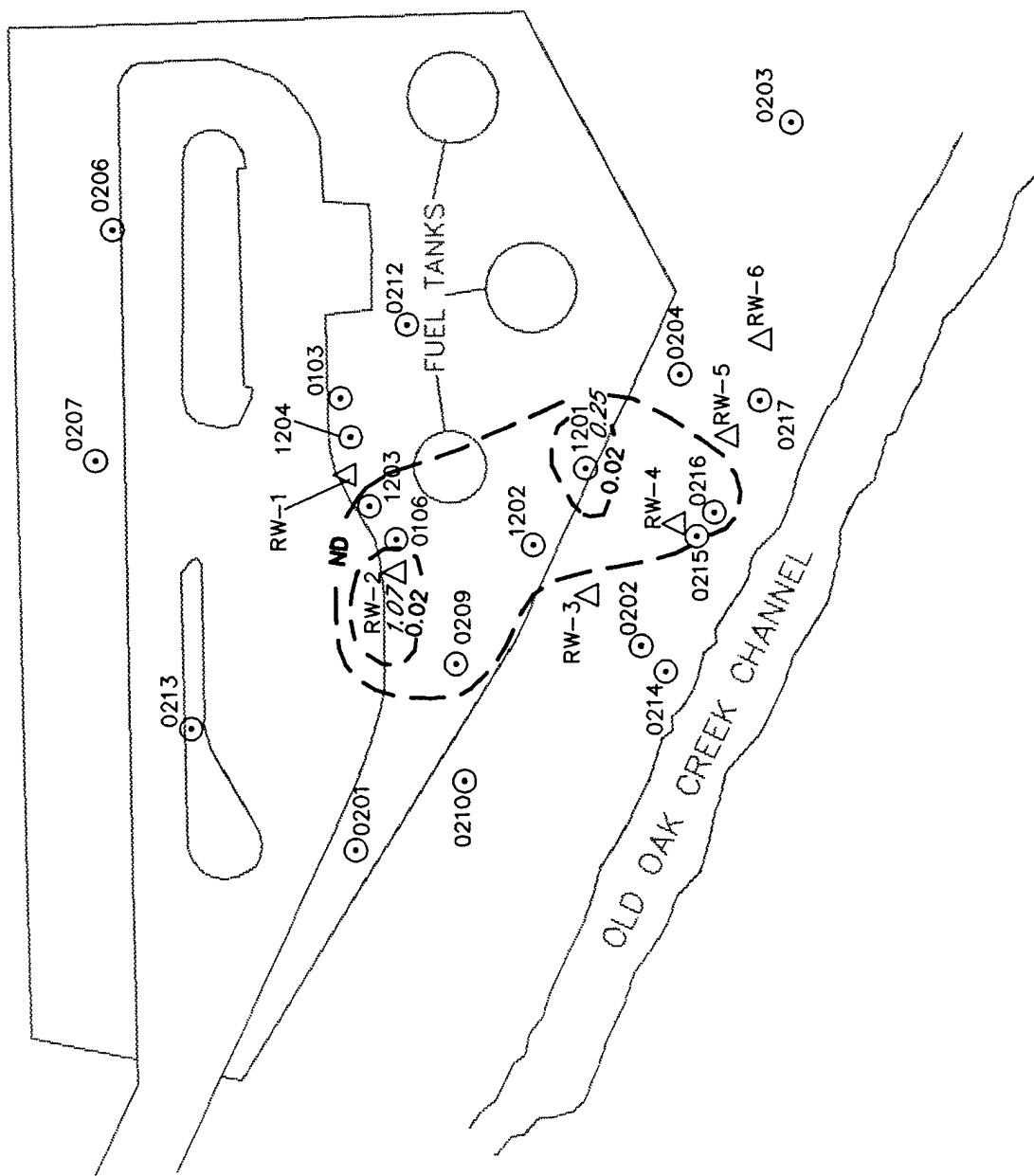


FIGURE 4.6

SITE 1

ISOCONTOUR OF OBSERVED PRODUCT THICKNESS, JUNE 1989

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska



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Denver, Colorado

LEGEND

- Δ RW-6 PRE-EXISTING RECOVERY WELL
- \odot 1203 610 PRE-EXISTING MONITOR WELL WITH BENZENE CONCENTRATION ($\mu\text{g/L}$)
- 200--- BENZENE CONCENTRATION IN $\mu\text{g/L}$, DASHED WHERE INFERRED
- ND NOT DETECTED

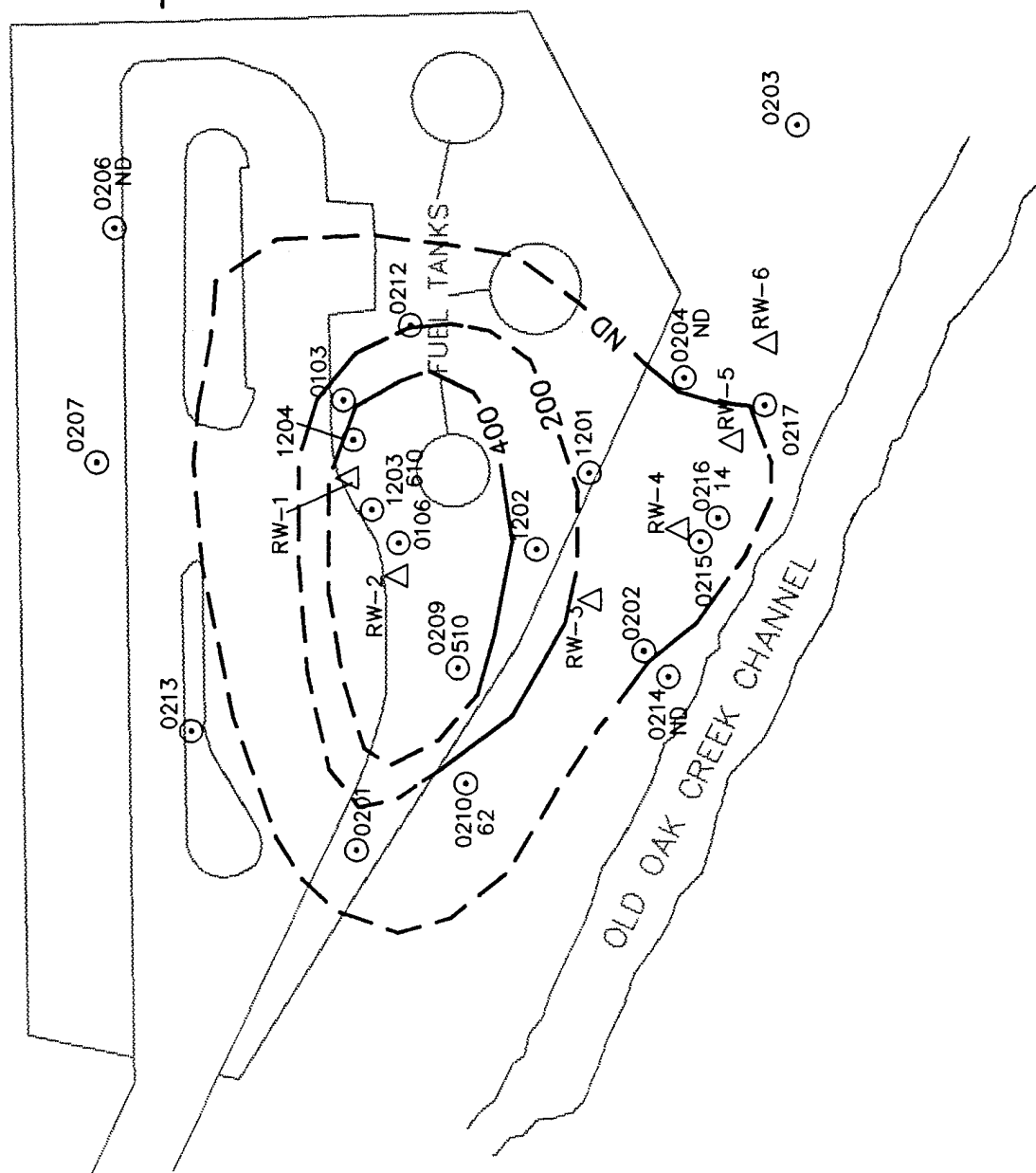


FIGURE 4.7
SITE 1
CONCENTRATION OF BENZENE IN
GROUNDWATER, JUNE 1989

155th Air Refueling Group
 Nebraska Air National Guard
 Lincoln Municipal Airport
 Lincoln, Nebraska



PARSONS
ENGINEERING SCIENCE, INC.

LEGEND

- △ RW-6 PRE-EXISTING RECOVERY WELL
- ⊙ 1203 PRE-EXISTING MONITORING WELL
- 10--- TPH IN mg/L 1989,
DASHED WHERE INFERRED
- 100--- TPH IN mg/L 1983,
DASHED WHERE INFERRED
- 50.9
1.8 TPH 1983 IN mg/L
TPH 1989 IN mg/L
- * REPORTED VALUE (2,005,900 mg/L)
NOT USED DUE TO PRESENCE OF
PRODUCT IN SAMPLE
- ND NOT DETECTED
- NA NOT ANALYZED

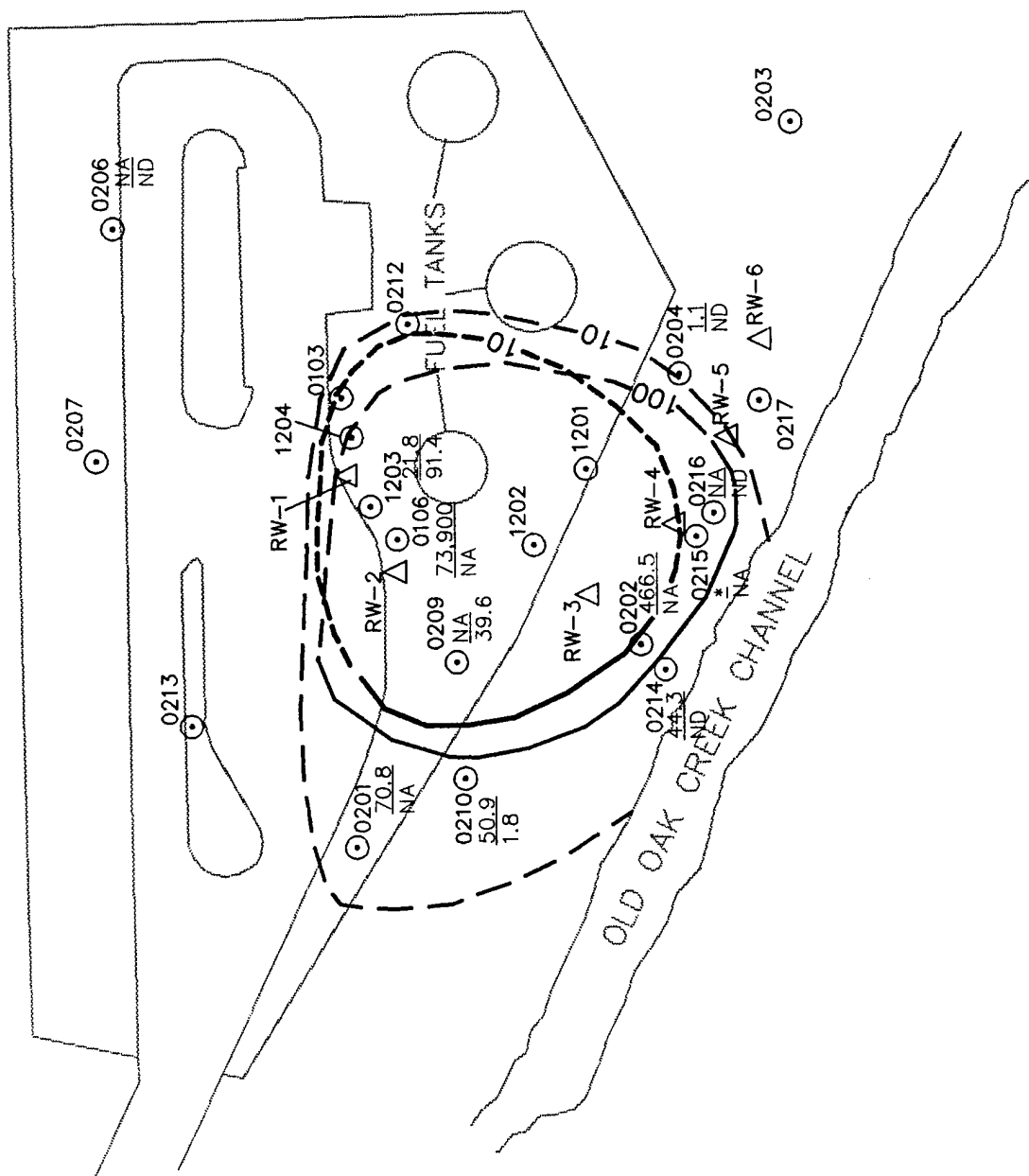


FIGURE 4.8
SITE 1

CONCENTRATION OF TOTAL PETROLEUM HYDROCARBONS (TPH) IN GROUNDWATER 1983 TO 1989

155th Air Refueling Group
Nebraska Air National Guard
Lincoln Municipal Airport
Lincoln, Nebraska

PARSONS
ENGINEERING SCIENCE, INC.

Denver, Colorado

concentrations of 39.6, 1.8, and 91.4 milligrams per liter (mg/L), respectively. The distribution of TPH in ground water is generally similar to that of benzene, toluene, ethyl benzene, and xylenes. Wells containing higher concentrations of these volatile organic compounds also contained relatively high concentrations of TPH. The correspondence of dissolved petroleum hydrocarbons in ground water with the presence of product films and fuel odors indicates that the petroleum hydrocarbons are not naturally occurring. As indicated in Figure 4.8, petroleum hydrocarbon concentrations appear to have generally decreased since 1983, perhaps due to a combination of dilution, biodegradation by indigenous microbial populations, and operation of the recovery system.

Common anions present in the ground water samples included fluoride, chloride, nitrate, and sulfate. Fluoride and chloride concentrations ranged from 0.35 to 1.03 mg/L and 6.4 to 95.8 mg/L, respectively. Levels of nitrate and sulfate ranged from 0.3 to 19.2 mg/L and 1.3 to 69.8 mg/L, respectively. Nitrite was not detected in any of the samples, however, samples did not meet quality control criteria. Technical holding times were violated for the anions nitrate and nitrite in all environmental samples. The resultant impact of holding time violation on anion values are estimated nitrate quantifications at an unknown bias and unusable nitrite quantifications. The concentrations of detected anions are similar to those detected in wells 0206 and 2-MW1, which are located upgradient of known or suspected sources of contamination at the facility.

Dissolved metals analyses of the ground water samples identified the presence of arsenic, barium, and selenium. Arsenic and barium were found in all well samples at concentrations ranging from 0.004 to 0.048 mg/L and 0.103 to 0.428 mg/L, respectively. Selenium was detected in five wells at concentrations of 0.002 to 0.017 mg/L. Barium concentrations in wells near to and downgradient of contamination sources were similar to levels observed in upgradient wells 0206 and 2-MW1, indicating that barium should not be considered a site contaminant. Detected levels of arsenic and selenium varied over approximately an order of magnitude; however, values are similar to concentrations of these constituents measured in upgradient wells 0206 and 2-MW1.

4.4 SITE 2 - ANALYTICAL RESULTS

Site 2 is the Old Oak Creek channel, where surface water quality, sediment quality, and ground water quality data were collected. Except for a culvert which drains the municipal airport, this water body, which was semi-stagnant in June 1989, is the only surface water at the facility.

4.4.1 Surface Water Quality

At Site 2, five surface water samples were collected from the Old Oak Creek channel, and one surface water sample was collected from the municipal airport outfall into Old Oak Creek. Sampling station locations are shown in Figure 4.1. At the time of sampling, the flow rate of the municipal airport outfall upstream of station 2-SW1 was estimated to be 1 gallon per minute (gpm), and the estimated flow rate of the outfall adjacent to station 2-SW5 was less than 1 gpm. The

remaining two outfalls into the creek, which are located near stations 2-SW6 and 2-SW4, were dry. All samples were analyzed for volatile and semivolatile organics, TPH, common anions, and heavy metals. Analytical results are summarized in Table 4.3.

Volatile and semivolatile organics were not detected in any of the surface water samples. TPH were detected at levels slightly above the detection limit of 1.0 mg/L in samples collected from stations 2-SW1 (1.6 mg/L) and 2-SW3 (1.3 mg/L) (Figure 4.1). Station 2-SW1 is located downstream of Site 1, and 2-SW3 is located immediately south of Site 1. The lack of TPH in the creek upstream of station 2-SW3 suggests that ground water containing TPH is discharging into the creek at Site 1.

Detectable concentrations of four common anions were noted in the Site 2 surface water samples. Anion concentrations upstream of the municipal airport outfall, located near station 2-SW2, are generally similar to those detected in ground water from upgradient wells 0206 and 2-MW1. An exception is the relatively high sulfate concentration at station 2-SW5 (158.8 mg/L). Fluoride, chloride, and sulfate concentrations in water from the municipal airport outfall and downstream of it (station 2-SW1) are also elevated, indicating that discharge from this outfall increases the levels of these constituents in the creek.

The metals arsenic and barium were detected at all of the sampling stations along the creek, while cadmium, chromium, lead, and mercury were not detected at any of the stations. Arsenic concentrations ranged from 0.006 to 0.017 mg/L, and the range of concentrations for barium was 0.037 to 0.141 mg/L. Arsenic concentrations were relatively uniform along the length of the creek, while barium concentrations were slightly higher at station 2-SW5 adjacent to a storm sewer outfall. In the past, spills occurring in Building 600 were also directed to this outfall (Hazardous Materials Technical Center, 1987). Selenium was detected at stations 2-SW2, 2-SW3, 2-SW5, and 2-SW6 at concentrations ranging from 0.002 to 0.005 mg/L. The sample from the municipal airport outfall at station 2-SW2 had one of the highest selenium concentrations at 0.005 mg/L.

4.4.2 Sediment Quality

Five stream sediment samples collected at Site 2 in the Old Oak Creek channel were analyzed for volatile and semivolatile organics, TPH, common anions, and total metals. These samples were collected from the upper 2 inches of the streambed sediments. A summary of analytical results of stream sediment samples is provided in Table 4.4.

The only volatile organic compound (VOC) detected in the sediment samples was toluene, which was found at sampling station 2-SD6 at a concentration of 45 micrograms per kilogram ($\mu\text{g/Kg}$) (Table 4.4). This station is slightly downstream of an outfall which connects to an oil-water separator. At least one semivolatile organic compound was detected in the sediment at each of the sampling stations. The most commonly detected compound was bis(2-ethylhexyl)phthalate, which was present at concentrations ranging from 750 to 2,500 $\mu\text{g/Kg}$. The highest concentrations of this compound occurred at sampling stations 2-SD5 and 2-SD1,

TABLE 4.4
SUMMARY OF ANALYTICAL RESULTS OF STREAM SEDIMENT SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | Units | ANALYTICAL RESULTS a/ | | | | |
|------|----------------|-----------------|-------|---------------------------------|--|---------------------------------|------------------------------------|--|
| | | | | Volatile Organics | | Semivolatile Organics | | |
| | | | | Benzene
($\mu\text{g/Kg}$) | Ethyl
Benzene
($\mu\text{g/Kg}$) | Toluene
($\mu\text{g/Kg}$) | Xylenes b/
($\mu\text{g/Kg}$) | Benzo(a)
anthracene
($\mu\text{g/Kg}$) |
| 2 | LANGB-2-SD1 | 06/19/89 | c/ | 9 U | 9 U | 9 U | 9 U | 840 |
| 2 | LANGB-2-SD3 | 06/19/89 | | 5 U | 5 U | 5 U | 5 U | 330 UJ |
| 2 | LANGB-2-SD7 e/ | 06/19/89 | | 10 U | 10 U | 10 U | 10 U | 330 U |
| 2 | LANGB-2-SD4 | 06/20/89 | | 11 U | 11 U | 11 U | 11 U | 360 U |
| 2 | LANGB-2-SD5 | 06/20/89 | | 9 U | 9 U | 9 U | 9 U | 750 |
| 2 | LANGB-2-SD6 | 06/20/89 | | 8 U | 8 U | 45 | 8 U | 250 U |
| | | | | | | | | 910 |
| | | | | | | | | 330 UJ |
| | | | | | | | | 330 U |
| | | | | | | | | 360 U |
| | | | | | | | | 1100 |
| | | | | | | | | 250 U |

TABLE 4.4 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF STREAM SEDIMENT SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | Units | ANALYTICAL RESULTS a/
Semivolatile Organics (Continued) | | | | | | | Total
Petroleum
Hydrocarbons
(mg/Kg) |
|------|----------------|-----------------|-------|--|---|---------------------|-------------------------|-------------------------|-------------------|--------|---|
| | | | | Benzo(k)
fluoranthene
(µg/Kg) | bis(2-Ethylhexyl)
phthalate
(µg/Kg) | Chrysene
(µg/Kg) | Fluoranthene
(µg/Kg) | Phenanthrene
(µg/Kg) | Pyrene
(µg/Kg) | | |
| | | | | | | | | | | | |
| 2 | LANGB-2-SD1 | 06/19/89 | | 890 | 1300 | 1300 | 2700 | 1900 | 2000 | 447.0 | |
| 2 | LANGB-2-SD3 | 06/19/89 | | 330 UJ | 870 J f/ | 330 UJ | 330 U | 330 U | 330 UJ | 335.0 | |
| 2 | LANGB-2-SD7 e/ | 06/19/89 | | 330 U | 860 | 330 U | 330 U | 330 U | 330 U | 489.0 | |
| 2 | LANGB-2-SD4 | 06/20/89 | | 360 U | 750 | 360 U | 360 U | 360 U | 360 U | 879.3 | |
| 2 | LANGB-2-SD5 | 06/20/89 | | 660 | 2500 | 1200 | 2800 | 2500 | 2300 | 2910.0 | |
| 2 | LANGB-2-SD6 | 06/20/89 | | 250 U | 250 U | 250 U | 250 U | 250 U | 250 U | 538.0 | |

TABLE 4.4 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF STREAM SEDIMENT SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| SITE | SAMPLE ID | DATE
SAMPLED | Units | ANALYTICAL RESULTS a/
Anions | | | | |
|------|---------------------------|-----------------|-------|---------------------------------|---------------------|-----------------------|--------------------|--------------------|
| | | | | Fluoride
(mg/Kg) | Chloride
(mg/Kg) | Nitrite
(mg/Kg) | Nitrate
(mg/Kg) | Sulfate
(mg/Kg) |
| 2 | LANGB-2-SD1 | 06/19/89 | | 68.5 J | 529.6 | <10.0 R ^{g/} | <10.0 J | 4014.9 |
| 2 | LANGB-2-SD3 | 06/19/89 | | 65.1 J | 517.1 | <10.0 R | <10.0 J | 8739.5 |
| 2 | LANGB-2-SD7 ^{d/} | 06/19/89 | | 57.2 J | 493.4 | <10.0 R | <10.0 J | 3513.2 |
| 2 | LANGB-2-SD4 | 06/20/89 | | 75.0 J | 531.4 | <10.0 R | <10.0 J | 8035.9 |
| 2 | LANGB-2-SD5 | 06/20/89 | | 60.7 J | 166.5 | <10.0 R | <10.0 J | 3052.0 |
| 2 | LANGB-2-SD6 | 06/20/89 | | 44.2 J | 383.8 | <10.0 R | <10.0 J | 2293.3 |

TABLE 4.4 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF STREAM SEDIMENT SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| ANALYTICAL RESULTS a/
Metals | | | | | | | | | | | |
|---------------------------------|----------------|-----------------|-------|--------------------|-------------------|--------------------|---------------------|-----------------|--------------------|---------------------|-------------------|
| SITE | SAMPLE ID | DATE
SAMPLED | Units | Arsenic
(mg/Kg) | Barium
(mg/Kg) | Cadmium
(mg/Kg) | Chromium
(mg/Kg) | Lead
(mg/Kg) | Mercury
(mg/Kg) | Selenium
(mg/Kg) | Silver
(mg/Kg) |
| 2 | LANGB-2-SD1 | 06/19/89 | | 3.9 J | 126 | 0.5 J | 9.3 | 18.2 J | 0.049 J | 0.5 UJ | 0.1 UJ |
| 2 | LANGB-2-SD3 | 06/19/89 | | 2.5 J | 119 | 0.4 J | 9.7 | 9.7 J | 0.048 J | 0.5 UJ | 0.1 UJ |
| 2 | LANGB-2-SD7 e/ | 06/19/89 | | 2.9 J | 103 | 0.3 J | 9.3 | 15.4 J | 0.038 J | 0.5 J | 0.1 UJ |
| 2 | LANGB-2-SD4 | 06/20/89 | | 3.3 J | 10.8 | 0.6 J | 9 | 92 J | 0.063 | 0.5 UJ | 0.2 J |
| 2 | LANGB-2-SD5 | 06/20/89 | | 5.1 J | 128 | 3.7 J | 29 | 58 J | 0.089 | 0.5 UJ | 2.7 J |
| 2 | LANGB-2-SD6 | 06/20/89 | | 2.3 J | 127 | 0.7 J | 17 | 12 J | 0.035 J | 0.5 UJ | 1.0 J |

a/ EPA Methods 624-CLPM, 625-CLPM, 418.1, SW3050; 6010/7000, and SMA 375.2 were used for June, 1989 samples. Organics included in EPA analyses methods but not included in table were not detected at any site. See Appendix E for complete analytical results.

Units of measure: $\mu\text{g/Kg}$ = micrograms per kilogram; mg/Kg = milligrams per kilogram.

b/ Value reported is total of m+p+o Xylenes.

c/ U = Compound was analyzed for but not detected. Value presented is the sample quantitation limit.

d/ UJ = The analyte was analyzed for, but was not detected above the level of the associated value.

The associated numerical value may not accurately or precisely represent the sample quantitation limit.
 e/ Duplicate of preceding sample.

f/ J = The numerical value represents a valid compound identification but is an estimated quantity because the associated quality control criteria were not met.

g/ R = The value is an unusable quantity (compound may or may not be present) because associated quality control criteria were exceeded excessively.

suggesting that the outfall waters entering the creek at 2-SD5 and upstream of 2-SD1 (municipal airport outfall) contain phthalates. While the phthalates are common lab contaminants, no method or field blanks showed phthalates. It is possible that low level phthalate contamination could be introduced through field procedures (specifically, contact with rubber sampling gloves). However, additional semivolatile compounds were detected at stations 2-SD1 and 2-SD5. These compounds include the polynuclear aromatic hydrocarbons (PNAs) benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene and pyrene. The locations of these additional compounds suggest that they originate, at least in part, from the outfall to the creek at station 2-SD5 and from the municipal airport outfall upstream of 2-SD1. PNAs are both naturally occurring and man induced, but are known to be strongly sorbed to sediments.

Detected levels of TPH were present at all sediment sampling locations. Concentrations ranged from a low of 335 milligrams per kilograms (mg/Kg) at station 2-SD3 to a high of 2,910 mg/Kg at 2-SD5. A fuel odor was noted during sample collection at 2-SD5. The relatively high concentrations of TPH at 2-SD5 and 2-SD4 suggest that the outfall at 2-SD5 has discharged hydrocarbon-containing waters to the creek.

The common anions fluoride, chloride, and sulfate were detected at all five sampling stations at concentrations ranging from 44.2 to 75.0 mg/Kg, 166.5 to 531.4 mg/Kg, and 2,293.3 to 8,739.5 mg/Kg, respectively. Nitrite and nitrate were not detected. The levels of detected anions in the sediment were considerably higher than those detected in ground water or surface water, indicating that the anions tend to become concentrated in the sediments. Fluoride and chloride concentrations generally did not vary considerably along the length of the creek. Sulfate levels however, were elevated at stations 2-SD3 and 2-SD4, indicating possible contributions from the outfall at 2-SD4.

Analysis for total metals revealed that detectable amounts of arsenic, barium, cadmium, chromium, lead, and mercury were present at all sediment sampling locations. Concentrations of arsenic, barium, and cadmium ranged from 2.3 to 5.1 mg/Kg, 10.8 to 128 mg/Kg, and 0.3 to 3.7 mg/Kg, respectively. Chromium, lead, and mercury concentrations ranged from 9 to 29 mg/Kg, 9.7 to 92 mg/Kg, and 0.035 to 0.089 mg/Kg, respectively. Selenium and silver were each found at three sampling stations. Similar to anions, metals concentrations in sediment samples tended to be higher than in surface or ground waters. Concentrations were generally highest at or a short distance downstream from one or both of the outfalls at stations 2-SD5 and 2-SD2.

4.4.3 Ground Water Quality

Well 2-MW1 at Site 2 was sampled for the same parameters as Site 1 ground water. Analytical results are summarized in Table 4.2. No volatile or semivolatile organics were detected. Common anions including fluoride (0.52 mg/L), chloride (47.4 mg/L), nitrate (18.2 mg/L), and sulfate (43.4 mg/L) were detected in the sample. A concentration of 1.8 mg/L of TPH was also reported. This TPH

detection may be a false positive, resulting from the presence of naturally-occurring organic material in the aquifer. Alternatively, the detection may indicate the presence of contaminant sources upgradient of Site 2. This concentration is slightly higher than the detection limit of 1.0 mg/L.

Three metals were detected in the well sample, including arsenic (0.004 mg/L), barium (0.197 mg/L), and chromium (0.003 mg/L). However, cadmium, lead, mercury, selenium, and silver were not detected. Reported levels of anions and metals in ground water from 2-MW1 are similar to those detected in well 0206, which is located at the upgradient boundary of Site 1. This similarity in concentrations indicates that, with the exception of TPH in well 2-MW1, both wells are generally representative of background conditions.

4.5 SITE 3 - ANALYTICAL RESULTS

Site 3 is the former tank-cleaning area at which ES completed four soil borings. One of the borings, 3-BH1, was subsequently completed as monitoring well 3-MW1. These activities provided information on the soil and ground water quality of the site.

4.5.1 Soil Quality

Six of the seven soil samples from Site 3 were analyzed for volatile and semivolatile organics, TPH, common anions, and metals. Sample BH-1-SS3, obtained from the 10.5 to 12 foot depth interval, was analyzed only for VOCs because ground water was encountered at 11 feet and only the top 6 inches could be sent to the laboratory. The small volume of the soil sample did not allow for performance of any other analyses. Analytical results of soil sampling are summarized in Table 4.5.

Volatile and semivolatile organics were not detected; however, TPH were detected in each of the soil borings drilled at Site 3. Hydrocarbon concentrations ranged from 52.7 to 113.0 mg/Kg. Samples obtained from the 0 to 1 and 4 to 5 foot depth intervals contained hydrocarbon concentrations of 52.7 to 87.1 mg/Kg and 113 mg/Kg, respectively. A deeper soil sample (6 to 10.5 feet) obtained from well 3-MW1 contained 107 mg/Kg TPH. Black discoloration was observed in the top 2 to 3 feet of borings 3-BH2 and 3-BH3.

The common anions fluoride, nitrate, and sulfate were present in all of the tested soil samples from Site 3 at concentrations ranging from 50.6 to 137.3 mg/Kg, 17.9 to 986.5 mg/Kg, and 98.0 to 1657.3 mg/Kg, respectively. Chloride was detected in four of the six tested samples at concentrations ranging from 42.9 to 208.8 mg/Kg. Nitrite was only detected in two samples at concentrations of 19.8 and 11.9 mg/Kg. Nitrite and nitrate levels tended to be highest in near-surface samples, while concentrations of the remaining three detected anions did not vary uniformly with depth. However, levels of fluoride, chloride, and sulfate were relatively high in samples from well 3-MW1.

Detectable concentrations of arsenic, barium, cadmium, chromium, and lead occurred in each of the samples tested. Concentrations of arsenic, barium, and

TABLE 4.5
SUMMARY OF ANALYTICAL RESULTS OF SOIL SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| ANALYTICAL RESULTS a/ | | | | | | | | | | | | | | |
|-----------------------|-------------|--------------|-------------------|-------------------|-----------------------|-----------------|--------------------|--------------------------------|------------------|------------------|-----------------|-----------------|-----------------|--|
| SITE | SAMPLE ID | DATE SAMPLED | SAMPLE DEPTH (ft) | Volatile Organics | | | | Total | | Anions | | | | |
| | | | | BENZENE (µg/Kg) | ETHYL BENZENE (µg/Kg) | TOLUENE (µg/Kg) | XYLENES b/ (µg/Kg) | Petroleum Hydrocarbons (mg/Kg) | FLUORIDE (mg/Kg) | CHLORIDE (mg/Kg) | NITRITE (mg/Kg) | NITRATE (mg/Kg) | SULFATE (mg/Kg) | |
| | | | | | | | | | | | | | | |
| 3 | BH-1-SS1 | 06/21/89 | 1.5-6.0 | 7 U c/ | 7 U | 7 U | 7 U | 75.8 | 137.30 J d/ | 208.8 | 19.8 R e/ | 894.7 J | 1657.3 | |
| 3 | BH-1-SS2 | 06/21/89 | 6.0-10.5 | 33 U | 33 U | 33 U | 33 U | 107.0 | 121.30 J | <10.0 | <10.0 R | 159.1 J | 1308.2 | |
| 3 | BH-1-SS3 | 06/21/89 | 10.5-11.0 | 7 U | 7 U | 7 U | 7 U | NA f/ | NA | NA | NA | NA | NA | |
| 3 | BH-2-SS1 | 06/21/89 | 0-1.0 | 6 U | 6 U | 6 U | 6 U | <50.0 | 73.90 J | 71.7 | 11.9 R | 107.6 J | 290.2 | |
| 3 | BH-2-SS2 | 06/21/89 | 4.0-5.0 | 6 U | 6 U | 6 U | 6 U | 113.0 | 98.50 J | 57.1 | <10.0 R | 17.9 J | 988.4 | |
| 3 | BH-3-SS1 | 06/21/89 | 0-1.0 | 29 U | 29 U | 29 U | 29 U | 52.7 | 73.8 J | 144.2 | <10.0 R | 986.5 J | 534.2 | |
| 3 | BH-3-SS2 | 06/21/89 | 4.0-5.0 | 6 U | 6 U | 6 U | 6 U | <50.0 | 53.20 J | <10.0 | <10.0 R | 81.5 J | 98.0 | |
| 3 | BH-4-SS1 g/ | 06/21/89 | 0-1.0 | 27 U | 27 U | 27 U | 27 U | 87.1 | 50.60 J | 42.9 | <10.0 R | 131.9 J | 142.9 | |
| 4 | BH-1-SS1 | 06/20/89 | 0-1.0 | NA | NA | NA | NA | 190 | 152.3 J | 637.2 | <10.0 R | 381.4 J | 3774.4 | |
| 4 | BH-1-SS2 | 06/20/89 | 4.0-5.0 | NA | NA | NA | NA | 74.9 | 82.80 J | 835.2 | <10.0 R | 319.2 J | 802.8 | |
| 4 | BH-2-SS1 | 06/20/89 | 0-1.0 | NA | NA | NA | NA | 74.8 | 72.40 J | 108.0 | <10.0 R | 1232.2 J | 1172.4 | |
| 4 | BH-2-SS2 | 06/20/89 | 4.0-5.0 | NA | NA | NA | NA | <50.0 | 99.60 J | 183.6 | <10.0 R | 1386.2 J | 1151.7 | |
| 4 | BH-3-SS1 | 06/20/89 | 0-1.0 | NA | NA | NA | NA | 51.8 | 103.1 J | 33.2 | <10.0 R | 47 J | 621.7 | |
| 4 | BH-3-SS2 | 06/20/89 | 4.0-5.0 | NA | NA | NA | NA | 75.5 | 49.60 J | 15.7 | <10.0 R | 36.3 J | 347.2 | |
| 4 | BH-4-SS1 h/ | 06/20/89 | 4.0-5.0 | NA | NA | NA | NA | 57.6 | 86.80 J | 47.0 | <10.0 R | 36.1 J | 560.2 | |
| 5 | BH-1-SS1 | 06/23/89 | 0-3.5 | 31 U | 31 U | 31 U | 31 U | 162.0 | 81.70 J | 85.4 | 30.5 R | 523.2 J | 1157.3 | |
| 5 | BH-1-SS2 | 06/23/89 | 3.5-9.5 | 31 U | 31 U | 31 U | 31 U | 104 | 116.70 J | 119.2 | <10.0 R | <10.0 J | 449.4 | |
| 6 | BH-1-SS1 | 06/20/89 | 2.0-6.0 | 6 U | 6 U | 6 U | 6 U | 84.9 | NA | NA | NA | NA | NA | |
| 6 | BH-1-SS2 | 06/20/89 | 6.0-10.5 | 6 U | 6 U | 6 U | 6 U | <50.0 | NA | NA | NA | NA | NA | |
| 6 | BH-1-SS3 | 06/20/89 | 10.5-13.5 | 6 U | 6 U | 6 U | 6 U | 84.7 | NA | NA | NA | NA | NA | |

TABLE 4.5 (Continued)
SUMMARY OF ANALYTICAL RESULTS OF SOIL SAMPLING
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| ANALYTICAL RESULTS a/ | | | | | | | | | | | |
|-----------------------|-------------|--------------|-------------------|-----------------|----------------|-----------------|------------------|--------------|-----------------|---------------------|----------------|
| Metals | | | | | | | | | | | |
| SITE | SAMPLE ID | DATE SAMPLED | SAMPLE DEPTH (ft) | ARSENIC (mg/Kg) | BARIUM (mg/Kg) | CADMIUM (mg/Kg) | CHROMIUM (mg/Kg) | LEAD (mg/Kg) | MERCURY (mg/Kg) | SELENIUM (mg/Kg) | SILVER (mg/Kg) |
| 3 | BH-1-SS1 | 06/21/89 | 1.5-6.0 | 4.8 J | 216 | 0.4 J | 23 | 7.2 J | 0.034 J | 0.7 J | 0.1 J |
| 3 | BH-1-SS2 | 06/21/89 | 6.0-10.5 | 4.4 J | 200 | 0.4 J | 21 | 6.7 J | 0.037 J | 0.5 UJ ⁱ | 0.2 J |
| 3 | BH-1-SS3 | 06/21/89 | 10.5-11.0 | NA | NA | NA | NA | NA | NA | NA | NA |
| 3 | BH-2-SS1 | 06/21/89 | 0-1.0 | 4.4 J | 199 | 0.4 J | 24 | 9.2 J | 0.030 J | 0.5 UJ | 0.2 |
| 3 | BH-2-SS2 | 06/21/89 | 4.0-5.0 | 4.5 J | 179 | 0.3 J | 27 | 6.9 J | 0.025 UJ | 0.6 J | 0.1 UJ |
| 3 | BH-3-SS1 | 06/21/89 | 0-1.0 | 3.7 J | 194 | 0.9 J | 24 | 81 J | 0.036 J | 0.5 UJ | 0.1 J |
| 3 | BH-3-SS2 | 06/21/89 | 4.0-5.0 | 3.2 J | 175 | 0.2 J | 11 | 5.3 J | 0.025 UJ | 0.8 J | 0.1 UJ |
| 3 | BH-4-SS1 g/ | 06/21/89 | 0-1.0 | 5.8 J | 204 | 0.4 J | 25 | 9.9 J | 0.039 J | 0.5 UJ | 0.2 J |
| 4 | BH-1-SS1 | 06/20/89 | 0-1.0 | 10.4 J | 246 | 1.5 J | 22 | 40 J | 0.026 J | 1 J | 0.1 UJ |
| 4 | BH-1-SS2 | 06/20/89 | 4.0-5.0 | 4.1 J | 180 | 0.2 J | 22 | 5.8 J | 0.025 UJ | 0.5 UJ | 0.1 UJ |
| 4 | BH-2-SS1 | 06/20/89 | 0-1.0 | 5.9 J | 802 | 0.4 J | 25 | 143 J | 0.029 J | 0.7 J | 0.1 UJ |
| 4 | BH-2-SS2 | 06/20/89 | 4.0-5.0 | 6.9 J | 284 | 0.32 J | 28 | 12 J | 0.035 J | 0.9 J | 0.1 J |
| 4 | BH-3-SS1 | 06/20/89 | 0-1.0 | 7.3 J | 221 | 0.3 J | 23 | 9.6 J | 0.040 J | 0.5 J | 0.1 UJ |
| 4 | BH-3-SS2 | 06/20/89 | 4.0-5.0 | 3.8 J | 164 | 0.2 J | 17 | 6.9 J | 0.025 UJ | 0.5 UJ | 0.1 UJ |
| 4 | BH-4-SS1 b/ | 06/20/89 | 4.0-5.0 | 3.4 J | 190 | 0.2 J | 5 | 6.2 J | 0.025 UJ | 0.5 UJ | 0.1 UJ |
| 5 | BH-1-SS1 | 06/23/89 | 0-3.5 | 2.6 J | 157 | 0.8 J | 21.1 | 4.9 J | 0.025 J | 0.7 J | 0.1 UJ |
| 5 | BH-1-SS2 | 06/23/89 | 3.5-9.5 | 3.8 J | 200 | 0.5 J | 27 | 6.4 J | 0.025 UJ | 0.5 UJ | 0.2 J |
| 6 | BH-1-SS1 | 06/20/89 | 2.0-6.0 | 5.3 J | 193 | 0.4 J | 25 | 9.5 J | 0.025 UJ | 0.5 UJ | 0.1 UJ |
| 6 | BH-1-SS2 | 06/20/89 | 6.0-10.5 | 3.8 J | 172 | 0.2 J | 20 | 9.1 J | 0.034 J | 0.5 UJ | 0.1 UJ |
| 6 | BH-1-SS3 | 06/20/89 | 10.5-13.5 | 1.5 J | 47 | 0.1 UJ | 12 | 4.2 J | 0.029 J | 0.5 UJ | 0.1 UJ |

a/ EPA Methods 624-CLPM, 625-CLPM, SW8080, 418.1, SW3050; 6010/7000, and SMA 375.2 were used for June, 1989 samples. Organics included in EPA

analysis method but not included in table were not detected at any site. See Appendix E for complete analytical results.

Units of measure: $\mu\text{g/Kg}$ = micrograms per kilogram; mg/Kg = milligrams per kilogram.

b/ Value reported is total of m + p + o Xylenes.

c/ U = Compound was analyzed for but not detected. Value presented is the sample quantitation limit.

d/ J = The numerical value represents a valid compound identification but is an estimated quantity because associated quality control criteria were not met.

e/ R = The value is an unusable quantity (compound may or may not be present) because associated quality control criteria were exceeded excessively.

f/ NA = Not analyzed.

g/ Duplicate of 3-BH-2-SS1.

h/ Duplicate of preceding sample.

i/ UJ = The analyte was analyzed for, but was not detected above the level of the associated value. The associated numerical value may not accurately

or precisely represent the sample quantitation limit.

cadmium ranged from 3.2 to 5.8 mg/Kg, 175 to 216 mg/Kg, and 0.2 to 0.9 mg/Kg, respectively. Chromium and lead concentrations ranged from 11 to 27 mg/Kg and 5.3 to 81 mg/Kg, respectively. The lead concentration of 81 mg/Kg, which is higher than the majority of lead levels detected during this study, occurred in the 0 to 1 foot sample from boring 3-BH3. This concentration is approximately four to six times the mean background values presented in Table 4.6. The lead level in the same boring at a depth of 4 to 5 feet was 5.3 mg/kg, indicating that the higher levels are limited to near-surface soils. Mercury was detected in four soil samples at levels ranging from 0.030 to 0.039 mg/Kg. Selenium was detected in three samples at concentrations of 0.6 to 0.8 mg/Kg. Silver was found in concentrations slightly above the detection limit of 0.1 mg/Kg in five samples. In spite of the relatively high lead level noted above, detected levels of metals at Site 3 did not exceed the background ranges listed in Table 4.6.

4.5.2 Ground Water Quality

The ground water sample collected from well 3-MW1 was analyzed for volatile and semivolatile organics, TPH, common anions, and dissolved metals. Volatile and semivolatile organics and petroleum hydrocarbons were not detected. The common anions fluoride, chloride, nitrate, and sulfate were detected at concentrations of 0.73, 100.4, 5.1, and 62.0 mg/L, respectively (Table 4.2). The metals arsenic (0.004 mg/L), barium (0.309 mg/L), chromium (0.005 mg/L), and selenium (0.010 mg/L) were also detected. Except for selenium, which had a slightly elevated concentration, levels of anions and metals in well 3-MW1 are similar to levels of these constituents detected in upgradient wells 0206 and 2-MW1.

4.6 SITE 4 - ANALYTICAL RESULTS

Site 4 is South Rock Road, where ES completed three shallow soil borings to characterize the soil quality at the site. In the past, the road was sprayed with waste oils, thinners, and diesel fuel for dust control.

4.6.1 Soil Quality

Six soil samples were collected from the 0 to 1 foot and 4 to 5 foot depth ranges in three boreholes at Site 4. The soils encountered consisted predominantly of dark brown to black clayey silt. Black discoloration and/or oil odors were noted throughout the full depths of borings 4-BH2 and 4-BH3, and in the top 3 feet of boring 4-BH1. The soil samples were analyzed for TPH, common anions, total metals, and PCBs (Table 4.5). PCBs were not detected. TPH were detected in all three borings, five of the six samples, at concentrations ranging from 51.8 to 190 mg/Kg, with the highest concentration occurring in the 0 to 1 foot interval of boring 4-BH1.

Common anions detected in each of the samples include fluoride, chloride, nitrate, and sulfate. Fluoride and chloride concentrations ranged from 49.6 to 152.3 mg/Kg and 15.7 to 835.2 mg/Kg, respectively. Nitrate levels ranged from 36.1 to 1,386.2 mg/Kg, while sulfate concentrations of 347.2 to 3,774.4 mg/Kg were detected. No nitrites were detected in any of the samples from Site 4. With the exception of sulfate, anion concentrations did not appear to vary uniformly with

TABLE 4.6
BACKGROUND CONCENTRATIONS OF METALS IN SOILS a/
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN NEBRASKA

| Element | United States b/ | | | Western United States b/ | | | Eastern United States b/ | | | Range From
Dragun (1988) |
|----------|-------------------|---------------------------------|--|--------------------------|---------------------------------|-------------------|--------------------------|---------------------------------|-------------------|-----------------------------|
| | Geometric
Mean | Estimated
Arithmetic
Mean | | Geometric
Mean | Estimated
Arithmetic
Mean | Observed
Range | Geometric
Mean | Estimated
Arithmetic
Mean | Observed
Range | |
| Arsenic | 5.2 | 7.2 | | 5.5 | 7.0 | <0.10-97 | 4.8 | 7.4 | <0.1-73 | 0.1-40 |
| Barium | 440 | 580 | | 580 | 670 | 70-5,000 | 290 | 420 | 10-1,500 | 100-3,500 |
| Cadmium | - c/ | - | | - | - | - | - | - | - | 0.01-7.0 |
| Chromium | 37 | 54 | | 41 | 56 | 3-2,000 | 33 | 52 | 1-1,000 | 5.0-3,000 |
| Lead | 16 | 19 | | 17 | 20 | <10-700 | 14 | 17 | <10-300 | 2.0-200 |
| Mercury | 0.058 | 0.089 | | 0.046 | 0.065 | <0.01-4.6 | 0.081 | 0.12 | 0.01-3.4 | 0.01-0.8 |
| Selenium | 0.26 | 0.39 | | 0.23 | 0.34 | <0.1-4.3 | 0.30 | 0.45 | <0.1-3.9 | 0.1-2.0 |
| Silver | - | - | | - | - | - | - | - | - | 0.01-5.0 |

a/ All values are reported in parts per million.

b/ Data from Shacklette and Boerngen, 1984. The 96th meridian is the dividing line between eastern and western United States.

c/ Dash (-) = value not included in referenced study.

location or depth. Sulfate levels in each of the borings were higher in the 0 to 1 foot interval than in the 4 to 5 foot interval.

Each of the samples analyzed contained detectable concentrations of arsenic, barium, cadmium, chromium, and lead. Concentrations of arsenic, barium, and cadmium ranged from 3.4 to 10.4 mg/Kg, 164 to 802 mg/Kg, and 0.2 to 1.5 mg/Kg, respectively. Concentrations of chromium and lead ranged from 5 to 28 mg/Kg and 5.8 to 143 mg/Kg, respectively. Mercury (0.026 to 0.040 mg/Kg) and selenium (0.5 to 1.0 mg/Kg) were each detected in four samples, while silver was detected in one sample at a concentration equal to the detection limit of 0.1 mg/Kg.

The barium, cadmium, and lead concentrations detected at a depth of 0 to 1 foot (802, 1.5, and 143 mg/Kg, respectively) are the highest levels of these constituents detected in this study. The barium concentration is 2.8 times higher than the next-highest barium level detected, while the lead concentration is 7 to 10 times the mean values for lead in soils reported in Table 4.6. The levels of these constituents in the 4 to 5-foot-deep sample in the same boring are considerably diminished, indicating a rapid decrease in concentration with depth. Such a decrease is consistent with the source of contamination being surficial, most probably associated with vehicular traffic on the road.

4.7 SITE 5 - ANALYTICAL RESULTS

Site 5 is the Army National Guard Oil Storage Area. ES drilled soil boring 5-BH1, which was subsequently converted to monitoring well 5-MW1. Soil and ground water quality data from this well are discussed below.

4.7.1 Soil Quality

The soil encountered in boring 5-BH1, which consisted predominantly of clay and silty clay, contained varying amounts of dark gray discoloration to a depth of 9 feet. In addition, fuel odors were noted from 3 feet to a depth of 7.5 feet. The two soil samples collected from well 5-MW1 were analyzed for volatile and semivolatile organics, TPH, common anions, and total metals. The results of these analyses are summarized in Table 4.5. No VOCs or semivolatile organic compounds were present in detectable concentrations. TPH were present in concentrations of 162 mg/Kg (0 to 3.5-foot depth interval) and 104 mg/Kg (3.5 to 9.5-foot depth interval). The majority of the deeper sample was obtained from the 3.5 to 7.5-foot depth interval.

Fluoride, chloride, and sulfate were present in detectable amounts in both soil samples at concentrations of 81.7 to 116.7 mg/Kg, 85.4 to 119.2 mg/Kg, and 449.4 to 1,157.3 mg/Kg, respectively. In addition, nitrite (30.5 mg/Kg) and nitrate (523.2 mg/Kg) were detected in the shallower sample. The nitrite level detected in the 0- to 3.5-foot depth interval is the highest concentration of this anion detected during this study, however samples did not meet quality control criteria.

Both of the samples from Site 5 contained some detectable concentrations of metals. Arsenic (2.6 to 3.8 mg/Kg), barium (157 to 200 mg/Kg), cadmium (0.5 to 0.8 mg/Kg), chromium (21.1 to 27 mg/Kg), and lead (4.9 to 6.4 mg/Kg) were detected in both soil samples collected. In general, levels of these metals did not vary significantly

with depth. In addition, mercury, selenium, and silver were each detected in one sample at levels of 0.025, 0.7, and 0.2 mg/Kg, respectively. Metals concentrations detected in Site 5 soils are less than or similar to mean background values for these metals in soils reported in Table 4.6.

4.7.2 Ground Water Quality

The ground water sample collected from well 5-MW1 did not contain detectable levels of volatile or semivolatile organics or TPH (Table 4.2). The sample did contain detectable levels of arsenic (0.025 mg/L) and barium (0.465 mg/L). Cadmium, chromium, lead, mercury, selenium, and silver were not detected. The common anions chloride, fluoride, nitrate, and sulfate were detected at concentrations of 1.0 mg/L, 1.0 mg/L, 32.0 mg/L, 1.5 mg/L, and 58.6 mg/L, respectively. Detected levels of metals and anions do not appear unusually high when compared with levels of these constituents in upgradient wells 0206 and 2-MW1.

4.8 SITE 6 - ANALYTICAL RESULTS

Site 6 is the Hydraulic Pressure Check-Unit Storage Area. ES drilled soil boring 6-BH1, later converted to monitor well 6-MW1. Soil and ground water quality data from this well are summarized below.

4.8.1 Soil Quality

Three soil samples were collected from boring 6-BH1 and analyzed for volatile and semivolatile organics, TPH, and metals. The soil samples were composited from the 2- to 6-foot, 6- to 10.5-foot, and 10.5- to 13.5-foot depth intervals. Analytical data for these samples are summarized in Table 4.5. No odor or discoloration that would indicate contamination were noted during drilling and sampling operations. Volatile and semivolatile organics were not detected; however, TPH were detected in the 2- to 6-foot and 10.5- to 13.5-foot depth intervals at concentrations of 84.9 and 84.7 mg/Kg, respectively.

The samples from the 2- to 6-foot, 6.0- to 10.5-foot, and 10.5- to 13.5-foot depth intervals were analyzed for total metals. Four metals, including arsenic (1.5 to 5.3 mg/Kg), barium (47 to 193 mg/Kg), chromium (12 to 25 mg/Kg), and lead (4.2 to 9.5 mg/Kg) were detected in all three samples. The highest concentration of each of these metals occurred in the shallowest sample. In addition, trace concentrations of cadmium and mercury were each detected in two soil samples. The levels of metals detected are comparable to the mean background values for these metals in soils contained in Table 4.6.

4.8.2 Ground Water Quality

The ground water sample collected from well 6-MW1 was analyzed for volatile and semivolatile organics, TPH, and metals. Volatile organics, semivolatile organics, and TPH were not detected (Table 4.2). Detectable levels of the metals arsenic (0.003 mg/L) and barium (0.197 mg/L) were reported; however, they were similar to levels detected in upgradient wells 0206 and 2-MW1.

SECTION 5

PRELIMINARY RISK EVALUATION

5.1 INTRODUCTION

An evaluation of the potential risks to human health and the environment from the information presented in previous sections is provided in this preliminary risk evaluation. The preliminary risk evaluation for Nebraska ANGB was performed using data collected during the SI. These previously-presented data include the site history (Section 1); demographic, land use, climatic, and ecological information (Section 2); and the results of the investigative program, including contaminant concentrations and geologic and hydrogeologic information (Section 4). The objectives of the preliminary risk evaluation are to provide qualitative information on the potential risks to human and environmental receptors due to the release or threat of release of hazardous substances from the six sites; to aid in identifying additional data needed to complete a quantitative risk assessment during the RI; and to provide information for the determination that no further action is required if risks to human and environmental receptors are not identified.

The results of the medium-specific investigations described in the previous sections were used to identify chemicals of concern, chemical concentrations within the release, general release characteristics, the affected environmental media, and exposed or potentially-exposed human or environmental receptors.

The initial steps of the preliminary evaluation were to:

- . Summarize the available chemical sampling data.
- . Establish criteria for selecting chemicals that are or may be related to the site, and that may have an adverse affect on human health or the environment in the concentrations present, and then select a group of chemicals for further evaluation.
- . Review the factors that affect migration of selected chemicals, and identify and evaluate the potential migration pathways.
- . Evaluate the potential toxicities associated with exposure to the selected chemicals by human or environmental receptors.
- . Identify potential hazards to human or environmental receptors that may be affected by the migration of contaminants along identified pathways.

Because the SI is a screening phase of investigation, the purpose of which is to confirm or deny the presence of contamination, the potential for data gaps exists. Therefore, detailed calculations to quantify risk to human health and the environment from the sites were not performed. Instead a qualitative approach was taken in which all potential receptors and exposure pathways were evaluated, and the potential importance of each exposure pathway was ascertained based on a comparison with standards or criteria and an evaluation of the likelihood of pathway completion. This evaluation was based on existing site information concerning migration pathways, the location and types of contaminants present, and the location of current and possible future receptors. Conservative assumptions were employed to ensure that potential exposure pathways were not excluded from consideration.

The preliminary evaluation assumes that no current or future remediation is performed at the site. This is referred to as the no-action alternative. This assumption is made to determine the need for remediation.

5.2 PRELIMINARY HUMAN HEALTH EVALUATION

5.2.1 Selection of Chemicals of Concern

During the selection of indicator chemicals, available information regarding the hazards of substances present at the site was evaluated. Data used in the selection of indicator chemicals and this preliminary human health evaluation were compiled from the SI field work performed at the base by ES. Summaries compiling the results of detected compounds from the investigations were provided in Tables 4.2 through 4.5. Compounds which were not detected in any samples were eliminated from further evaluation. Data that did not meet quality control criteria were not used. Nitrite was the only parameter affected. In addition, inorganic chemicals which are essential nutrients or are toxic only at high doses were excluded from further analysis. These included chloride and sulfate.

Twenty-four compounds were identified as potential chemicals of concern in this evaluation. They are:

- . arsenic,
- . barium,
- . benzene,
- . bis(2-ethylhexyl)phthalate,
- . cadmium,
- . chromium,
- . ethyl benzene,
- . fluoride,
- . lead,
- . mercury,

- . nitrate,
- . PNAs:
 - benzo(a)anthracene
 - benzo(a)pyrene
 - benzo(b)fluoranthene
 - benzo(k)fluoranthene
 - chrysene
 - fluoranthene
 - phenanthrene
 - pyrene
- . selenium,
- . silver,
- . toluene,
- . TPH, and
- . xylenes.

Analytical data were reviewed by medium to characterize contamination at each of the six sites at Nebraska ANGB. Not all compounds were detected at all sites or in all media. The maximum concentrations for each chemical provide an indication of the magnitude of chemical contamination in the analyzed samples. The maximum values are used in subsequent sections to estimate the potential for adverse health effects.

Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene are members of the diverse PNA class of compounds. These compounds are present throughout the environment from both natural and anthropogenic sources, but were detected only in the sediments at Nebraska ANGB. Although TPH includes many compounds, this risk evaluation focuses on the gasoline and fuel oil components of TPH.

Many of the inorganic compounds selected as chemicals of potential concern may be present at naturally-occurring background concentrations. However, background concentrations are not reliably known at Nebraska ANGB. Therefore, a statistical analysis to determine outliers (values outside of the normal range) was performed to establish an expected range of concentrations that may represent baseline conditions. The outlier values were tested at the 95 percent confidence interval, meaning that concentrations identified as outliers have a 95 percent probability that they are not part of the same population as other concentrations. Thus, the outliers may indicate contamination. Outlier values were identified in soil samples taken at Site 4 for arsenic, barium, cadmium, and lead. Other inorganic chemicals including chromium, mercury, selenium, silver, fluoride, and nitrate appear to be present in baseline concentrations at all sites. Although many of these inorganic compounds

may be naturally occurring and representative of baseline conditions, they were retained as chemicals of concern for evaluation. The effect of the outlier analysis is discussed by site in the hazard assessment.

Toxicity data exists for each of chromium's (Cr) two common valence states, Cr (III) and Cr (VI). Because Cr (VI) is quite soluble and is not sorbed to any significant degree by clays or hydrous metal oxides, it was assumed that all chromium found in water was in the Cr (VI) state. Because the Cr (III) state forms an insoluble precipitate with hydroxide ions in water, all chromium found in soils and sediments was assumed to be in the Cr (III) state.

5.2.2 Exposure Assessment

5.2.2.1 Environmental Fate and Transport

An evaluation of the environmental fate and transport of the selected chemicals of concern for Nebraska ANGB can help determine the potential for migration in the environment and the potential for exposure to the contaminants. The environmental fate and transport of contaminants is dependent upon the physical and chemical properties of the compounds, the environmental transformation processes affecting them, and the media through which they migrate. In this section the chemical and physical properties of the chemicals of concern are presented, and the relevance of these properties to environmental fate and transport is discussed. In addition, mechanisms of chemical migration into air, ground water, and surface water and processes of biotransformation and bioaccumulation are discussed in relation to the environmental fate and transport of the chemicals of concern.

Chemical and Physical Properties of the Chemicals of Concern

Physical and chemical properties of the chemicals of concern will affect the extent to which they may migrate through the environment. Table 5.1 summarizes several of these properties for many of the selected chemicals of concern.

The water solubility of a substance is a critical property affecting environmental fate. Highly-soluble chemicals can be rapidly leached from wastes and soils and are generally mobile in ground water. Solubilities can range from less than 1 mg/L to totally miscible, with most common organic chemicals falling between 1 mg/L and 1,000,000 mg/L (Lyman et al., 1982). The solubility of chemicals which are not readily soluble in water may become enhanced in the presence of organic solvents (e.g., toluene) which themselves are more soluble in water.

Volatilization of a compound will depend on its vapor pressure, water solubility, and air diffusion coefficient. Highly water-soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Vapor pressure, a relative measure of the volatility of chemicals in their pure state, ranges from roughly 0.001 to 760 millimeters of mercury (mm Hg) for liquids. The Henry's Law Constant, which combines vapor pressure with solubility, is more appropriate than vapor pressure alone for estimating releases from water to air for compounds having Henry's Law Constants. Compounds with Henry's Law Constants greater than 10^{-3} atmospheres - cubic meter per mole ($\text{atm}\cdot\text{m}^3/\text{mole}$) can be expected to readily volatilize from water; those with values ranging from 10^{-3} to 10^{-5} are

TABLE 5.1
RELEVANT PHYSICAL AND CHEMICAL PROPERTIES
OF DETECTED CHEMICALS
155TH AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT
LINCOLN, NEBRASKA

| Chemical | CAS/
Number | Water Solubility
(mg/L) ^{b/} | Vapor Pressure
(mm Hg) ^{c/} | Henry's Law
Constant
(atm-m ³ /mole) ^{d/} | K _{OC}
(mL/g) ^{e/} |
|--------------------------------|----------------|--|---|---|---|
| Arsenic | 7440-38-2 | -- | -- | -- | -- |
| Barium | 7440-39-3 | -- | -- | -- | -- |
| Benzene | 71-43-2 | 1.75E+03 | 9.52E+01 | 5.59E-03 | 83 |
| Benzo(a) Anthracene | 56-55-3 | 5.70E-03 | 2.20E-08 | 1.16E-06 | 1,380,000 |
| Benzo(b) Fluoranthene | 205-99-2 | 1.40E-02 | 5.00E-07 | 1.19E-05 | 550,000 |
| Benzo(k) Fluoranthene | 207-08-9 | 4.30E-03 | 5.10E-07 | 3.94E-05 | 550,000 |
| Benzo(a) Pyrene | 50-32-8 | 1.20E-03 | 5.60E-09 | 1.55E-06 | 5,500,000 |
| Bis(2-Ethylhexyl)
Phthalate | 117-81-7 | -- | -- | -- | -- |
| Cadmium | 7740-43-9 | -- | -- | -- | -- |
| Chromium | 7440-47-3 | -- | -- | -- | -- |
| Chrysene | 218-01-9 | 1.80E-03 | 6.30E-09 | 1.05E-06 | 200,000 |
| Ethyl Benzene | 100-41-4 | 1.52E+02 | 7.00E+00 | 6.43E-03 | 1,100 |
| Fluoranthene | 206-44-0 | 2.06E-01 | 5.00E-06 | 6.46E-06 | 38,000 |
| Fluoride | 7782-41-4 | -- | -- | -- | -- |
| Lead | 7439-92-1 | -- | -- | -- | -- |
| Mercury | 7439-97-6 | -- | 2.00E-03 | -- | -- |
| Nitrate | 85-01-8 | -- | -- | -- | -- |
| Phenanthrene | 129-00-0 | 1.00+00 | 6.80E-04 | 1.59E-04 | 14,000 |
| Pyrene | 7782-49-2 | 1.32-01 | 2.50E-06 | 5.04E-06 | 38,000 |
| Selenium | 7440-22-4 | -- | -- | -- | -- |
| Silver | 108-88-3 | -- | -- | -- | -- |
| Toluene | 1330-20-7 | 5.35E+02 | 2.81E+01 | 6.73E+03 | 300 |
| Xylenes | | 1.98E+02 | 1.00E+01 | 7.04E-03 | 240 |

a/ CAS = Chemical Abstract Service.

b/ mg/L = milligrams per liter.

c/ mm Hg = millimeters of mercury.

d/ atm-m³/mole = atmospheres-meters cubed per mole.

e/ K_{OC} = organic carbon partition coefficient; mL/g = milliliters per gram.

associated with possibly significant but not facile volatilization, while compounds with values less than 10^{-5} will only volatilize from water to a limited extent (Lyman et al., 1982).

The organic carbon partition coefficient (K_{oc}) reflects the propensity of a compound to sorb to organic matter found in soil. The normal range of K_{oc} values is 1 to 10^7 milliliters per gram (mL/g), with higher values indicating greater sorption potential. Chemicals which have a strong tendency to sorb to organic matter (i.e., chemicals with high K_{ocs}) will move more slowly in the environment than chemicals with low K_{ocs} .

Chemicals of concern were classified into several categories according to their similarity in chemical structure and/or physiochemical properties (factors which would influence mobility in the environment) in Tables 4.2 to 4.5. The organic chemical categories and the chemicals of concern within each category as well as the inorganics are listed below:

- volatile organics: benzene, ethyl benzene, toluene, xylenes.
- semivolatile organics: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, fluoranthene, phenanthrene, pyrene.
- anions: fluoride, nitrate.
- metals: arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver.
- other: TPH.

Toxicity Profiles For the Chemicals of Concern

Toxicity information for both human and environmental receptors is included in the following paragraphs.

Arsenic. Arsenic is a naturally-occurring metalloid which may be present in the environment in a number of different valence states. It may be a constituent of both organic and inorganic compounds. Arsenic is widely used by industry as an alloying agent, in ore concentrating processes, and as a pesticide.

Arsenic is generally extremely mobile in aquatic environments, and cycles through air, water, and soils. Its precise fate in a particular environment depends upon the complex interactions of a number of factors, including oxidation potential (Eh); pH; the presence and concentrations of metal sulfide and sulfide ions, phosphorus minerals, and iron; temperature; salinity; and the distribution and composition of the biota. Of these factors, Eh and pH have been shown to be most critical. A number of studies have described the equilibrium chemistry of arsenic, but reaction rates remain generally unknown. Sediments and soils often act as a sink for arsenic by adsorption onto clays, iron oxides, aluminum hydroxide, and organic materials.

Arsenic is toxic to aquatic animal species, and induces its toxic effects via enzyme inhibition. In aquatic species, arsenic has induced death following acute exposures and has caused death and deformity following chronic exposures. Arsenic can

bioaccumulate in aquatic vertebrates and invertebrates, but bioconcentration occurs to a greater extent in invertebrates. Quantitative data on the toxicity of arsenic to terrestrial wildlife species are limited, but arsenic has been shown to induce death in wild rabbits and hares following acute oral exposures. In laboratory species, arsenic has been found to be carcinogenic, teratogenic, embryotoxic, and fetotoxic.

Arsenic has been associated with skin, lung, and liver cancers. Acute arsenic poisoning can cause nausea, vomiting, and diarrhea. In severe cases, arsenic poisoning may produce shock followed by coma and death. Chronic arsenic poisoning may cause disturbances of the digestive system, liver damage, and disturbances of the blood, kidneys, or nervous system.

Barium. Barium is a relatively common, naturally-occurring, trace metal which occurs in the 2+ valence state in natural waters. Barium is associated with potassium in felsic igneous rocks and with lead-zinc sulfide ores. It is produced commercially by the mining of barite.

Barium is considered to have intermediate mobility, probably limited by the solubility of barite in a particular environment. Barium may be relatively strongly sorbed onto certain clays, limiting its mobility. It is not known to biomagnify. The soluble form may be toxic to certain species.

In most natural waters, there is sufficient sulfate or carbonate to precipitate the barium present in the water, rendering it an insoluble nontoxic compound. As the physical and chemical properties of barium will generally preclude the existence of the toxic soluble form under usual freshwater conditions, EPA has not established criteria for the protection of aquatic life.

Barium is not a known carcinogen, although soluble barium salts (i.e. the chloride and sulfide salts) are poisonous when ingested orally. Exposure to the barium sulfide, oxide, and carbonate compounds usually causes irritation of the eyes, throat, nose, and skin. Adverse effects in humans following oral exposure to soluble barium compounds include gastroenteritis, muscular paralysis, hypertension, ventricular fibrillation, and central nervous system damage.

Benzene. Benzene is a colorless aromatic hydrocarbon with a characteristic odor. Benzene was widely used in the past as a solvent and as an octane-raising additive in gasoline. Presently, benzene is used primarily in the chemical industry where it is used as a starting or intermediate material for the synthesis of many other organic compounds.

Benzene has been shown to be mobile in the soil/ground water system. It is relatively soluble in ground water and may be transported through sandy soils and soils of low organic content. The amount of benzene sorbed to the soil increases with increasing organic content. Benzene is highly volatile, and volatilization in surficial soils is probably an important transport mechanism. However, sorption of benzene vapors onto soil particles may slow the vapor-phase transport. Hydrolysis is not expected to be an important process for benzene transport. Data on the biodegradation of benzene are inconclusive. There is some evidence of gradual biodegradation at low concentrations by aquatic organisms, but the compound is

considered fairly resistant to biodegradation. The rate of biodegradation may be enhanced in the presence other hydrocarbons.

Data are not considered sufficient to develop ambient water quality criteria for benzene. No information is available on the toxicity of benzene to terrestrial wildlife, domestic animals, birds, or plants. Toxic effects in laboratory animals include central nervous system effects, hematological effects, and immune system depression.

Benzene is readily absorbed following oral and inhalation exposure. The toxic effects of benzene in humans following exposure by inhalation is the same as that for laboratory animals and includes central nervous system effects, hematological effects, and immune system depression. In humans, acute exposures to high concentrations of benzene vapors has been associated with dizziness, nausea, vomiting, headache, drowsiness, narcosis, coma, and death. Chronic exposure to benzene vapors can produce reduced leukocyte, platelet, and red blood cell levels.

Chronic exposure to benzene is associated with leukemia and bone marrow damage. In addition, the compound is a central nervous system depressant at high concentrations, and may cause acute narcotic reactions.

Bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate, also known as diethylhexylphthalate, is a common laboratory contaminant. It is used in vacuum pumps and, when heated to decomposition, it emits acrid smoke. As a group, phthalate esters are widely distributed in the environment by anthropogenic and perhaps natural sources. They have been found in well and drinking water, oil, soil, air, plants, fish, food, animals, and humans. Phthalate ester contamination in surface water residues has been correlated with drainage from industrial or heavily polluted areas.

A variety of organisms can accumulate phthalate esters and they have become concentrated in animal and human tissues and organs. Under aerobic conditions, microbial systems can degrade phthalate esters, but under anaerobic conditions, bis(2-ethylhexyl) in particular, ceases to degrade. In determining the environmental fate of phthalate esters, bioaccumulation, biotransformation, and biodegradation are probably the most important processes.

No ambient water quality criteria are available. Information on the toxicity of bis(2-ethylhexyl)phthalate to wildlife is unavailable. Bis(2-ethylhexyl)phthalate is readily absorbed following oral or inhalation exposure.

Cadmium. Cadmium is a transitional metal which occurs widely in nature, generally in association with lead or zinc ores. Elemental cadmium is insoluble in water, but many cadmium compounds are quite soluble. The general population is widely exposed to low levels of cadmium in drinking water, food, and in industrial settings.

Cadmium is relatively mobile in the environment compared to most other heavy metals. Cadmium is less mobile in alkaline than in acidic waters, and pH is a major factor influencing mobility. Sorption processes affect cadmium less than most other heavy metals. However, the mobility of cadmium can be reduced by sorption onto

clays, hydrous iron, aluminum and manganese oxides, and organic materials. Volatilization is not an important process in aqueous environments.

In aquatic systems, hardness affects the toxicity of cadmium. Species also exhibit different sensitivities to cadmium. There is no evidence that cadmium is an essential mineral. Mammals have no effective mechanism for the elimination of ingested cadmium; therefore, with time, the cadmium tends to accumulate in the liver and kidneys. It tends to be very persistent in the kidney and can cause renal tubular damage. Toxic effects include decreased growth rates, anemia, infertility, fetus abnormalities, abortions, kidney disease, intestinal disease, and hypertension.

Cadmium compounds, when inhaled, have been associated with pulmonary cancer. The inhalation of cadmium dust or fumes affects the respiratory tract and kidneys. Exposure to high concentrations may result in pulmonary edema and death. Ingestion of cadmium results in gastrointestinal poisoning.

Chromium. Chromium (Cr) is a transition element, occurs in nature principally as the trivalent ion Cr^{+3} , although valence states ranging from -2 to +6 have been reported. Cr exists in two oxidation states in aqueous systems: Cr(III) and Cr(VI). The hexavalent form, Cr(VI), is quite soluble, existing in solution as a complex anion, and is not sorbed to any significant degree by clays or hydrous metal oxides. It is, however, sorbed strongly to activated carbon. Cr(VI) is a moderately strong oxidizing agent and reacts with reducing materials to form trivalent Cr. The trivalent form, Cr (III), reacts with aqueous hydroxide ions to form insoluble chromium hydroxide ($\text{Cr}(\text{OH})_3$). Most of the hydroxide form precipitates to the benthic zone in natural waters directly or by sorption.

Chromium is bioaccumulated by aquatic organisms, and passage of chromium through the food chain has been demonstrated. Cr has a low inherent toxicity to fish and animals, moderate toxicity to plants, and low potential for biomagnification in the food chain. Cr is an essential trace element for animals and is considered non-essential for plants.

In aquatic systems, plants and polychaete worms appear to be the most sensitive groups tested. The toxicity of Cr(VI) to aquatic species appears to increase as pH and/or hardness decreases. Bioaccumulation has been found to vary among species; concentrations are normally highest at lower trophic levels and lowest with the top predators, indicating that biomagnification does not occur. Ambient water quality criteria have been established for Cr(VI).

Following oral exposure, absorption of Cr(III) is low while absorption of Cr(VI) is high. Chromium is an essential micronutrient and is not toxic in trace quantities. High levels of soluble Cr(VI) and Cr(III) can produce kidney and liver damage following acute oral exposure; target organs affected by chronic oral exposure remain unidentified. Chronic inhalation exposure may cause respiratory system damage. Further, epidemiological studies of worker populations have clearly established that inhaled Cr(VI) is a human carcinogen; the respiratory passages and the lungs are the target organs. Inhalation of Cr(III) or ingestion of Cr(VI) or (III) has not been associated with carcinogenicity in humans.

Ethyl Benzene. Ethyl benzene is a colorless aromatic liquid. It is used in industry as a resin solvent and in the conversion to styrene monomer. No empirical studies on the bioaccumulation of ethyl benzene were found. No information on the toxicity of ethyl benzene to terrestrial wildlife or birds was available.

In humans, short-term inhalation exposure to ethyl benzene can result in sleepiness, fatigue, headache, and mild eye and respiratory irritation.

Fluoride. Fluorine is used in the manufacture of fluorochemicals, plastics, and rocket propellant. Fluorine is an intermediate for sulfur hexafluoride, chlorine trifluoride, bromine trifluoride, uranium hexafluoride, molybdenum hexafluoride, perchloryl fluoride, and oxygen difluoride. The fluoride ion is extremely stable, and therefore fluoride rather than fluorine is found in nature.

Fluoride is nonessential to plants and microbes and is not toxic to crops or microbes at background concentrations. High fluoride concentrations may accumulate in a soil plant system artificially through the addition of phosphate fertilizers, inorganic or organic pesticides, and through air contamination near industrial sites. Some varieties of crops are more tolerant of fluoride than others. Adverse crop effects often are not evidenced before the plant level exceeds that deemed safe for animal or human consumption.

Large doses of fluoride can cause very severe nausea, vomiting, diarrhea, abdominal burning and cramp-like pains. Also, loss of weight, anorexia, anemia, and dental defects are among the common findings in chronic poisoning. When added to the water supply in small amounts, fluoride has been shown to decrease the incidence of tooth decay.

Lead. Elemental lead is heavy, ductile, and bluish-white in color. It is widely used in industry because of its softness, resistance to corrosion and radiation, and high density. Lead is also used as a paint pigment, in solders, and in storage batteries.

The concentration and mobility of lead is controlled primarily by sorption. The tendency for lead to form complexes with naturally-occurring organic materials increases its adsorptive affinity for clays and other mineral surfaces. At low pH values, sorption and precipitation are not nearly as effective in removing lead from solution, so that lead is much more mobile in acidic waters than at higher pH values. In alkaline and circumneutral waters, removal of lead by sorption and precipitation may occur relatively quickly. Bioaccumulation may also be an important fate process.

Lead is generally considered a highly toxic contaminant because it is not an essential nutrient to either plants or animals. Lead bioaccumulates in animal tissues, but has a low potential for biomagnification in the food chain. The solubility of lead is dependent on water hardness, and lead is considered 20 to 100 times more toxic in soft water. In aquatic environments, most lead is found in bottom sediments and is therefore a concern more in benthic organisms than in planktonic or pelagic forms. Toxicity of lead in water is dependent on pH, organic materials, and the presence/absence of other metals.

The primary mechanism of acute toxicity of lead to freshwater organisms is unknown. Invertebrate species appear more sensitive than vertebrate species. Lead inhibits plant growth, and reduces photosynthesis, mitosis, and water absorption.

Lead is stored in humans in bone, kidneys, and liver. The major adverse effects in humans caused by lead include alterations in the hematopoietic and nervous systems. The toxic effects are generally related to the concentration of this metal in blood. Toxic blood concentration in children and in sensitive adults can cause severe, irreversible brain damage, encephalopathy, and possible death. Physiological and biochemical effects that occur even at low levels include enzyme inhibition, elevated erythrocyte protoporphyrin, interference with vitamin D metabolism, cognitive dysfunction in infants, electrophysiological dysfunction, and reduced childhood growth.

Mercury. Mercury is a silvery, liquid, metallic element. It is used in barometers, thermometers, hydrometers, pyrometers, mercury arc lamps producing ultraviolet rays, switches, fluorescent lamps, mercury boilers, extracting gold and silver ores, making amalgams, and dentistry.

In the environment, mercury readily bioaccumulates. It is strongly sorbed to inorganic and organic particulates. Precipitation of mercury sulfide can result when mercury-laden sediments are deposited in reducing zones. Mercury in sediments can be remobilized through biomethylation. Volatilization of dimethyl mercury may occur in the environment.

In birds and mammals mercury can adversely affect reproduction, growth and development, behavior, blood chemistry, coordination, vision, hearing, and metabolism. Symptoms of mercury poisoning in birds include muscular incoordination, hyperactivity, and withdrawal. Mercury toxicity in birds depends on the form of the element, route of exposure, and age of the animal. Organic forms of mercury, such as methylmercury, are more toxic than inorganic mercury.

In mammals, organomercury compounds are more toxic than the inorganic form. Larger mammals such as the mule deer appear to be more resistant than smaller animals such as cats, dogs, pigs, monkeys, and river otters. This may be related to differences in metabolism and detoxification rates. Mercury is not known to be readily taken up by plants. Symptoms of toxicity to plants include stunting of seedling growth and root development, and an inhibition of photosynthesis causing yield reductions.

In humans, elemental and inorganic mercury are absorbed following inhalation exposure or contact with skin and the gastrointestinal tract. Spilled and heated elemental mercury is particularly hazardous. Occupational exposure of workers to elemental mercury vapors has been associated with mental disturbances, tremors, and gingivitis. The central nervous system is a major target for organic mercury compounds. Adverse effects in humans from exposure to organic mercury compounds have included destruction of cortical cerebral neurons, damage to Purkinje cells, and lesions of the cerebellum. Clinical symptoms following exposure to organic mercury compounds have included parasthesia, loss of sensation in extremities, ataxia, and hearing and visual impairment. A primary target organ for

inorganic compounds is the kidney. Human exposure to inorganic mercury compounds has been associated with anuria, polyuria, proteinuria, and renal lesions.

Nitrate. All plants and animals, as well as most microorganisms, depend on a source of combined nitrogen in their nutrition. The cyclic transformation of nitrogenous compounds is essential for supplying required forms of nitrogen. The turnover of nitrogen through its cycle involves a number of biologically-mediated processes. Ammonia from decomposing organic matter is microbiologically oxidized to nitrite (NO_2) which is then converted to nitrate (NO_3).

The environmental fate of nitrogen varies considerably depending on whether it is present in oxidized or reduced form. Nitrate in soils is freely mobile, but when reduced to ammonium (NH_4) it is immobilized by cation exchange and adsorption processes.

The toxicity of nitrates is due to its conversion to nitrites. Infants are particularly susceptible to nitrate toxicity due to their high gut content of nitrate-reducing bacteria, their lower-enzymatic capacity to reduce methemoglobin to hemoglobin, and the presence of hemoglobin F, which is more susceptible to oxidation. Methemoglobin is a toxic form of hemoglobin that is produced by oxidizing agents such as nitrites. The most sensitive population with respect to the formation of methemoglobin has been determined to infants.

Ingestion of large amounts of nitrates may have serious or even fatal effects. The symptoms are dizziness, abdominal cramps, vomiting, bloody diarrhea, weakness, convulsions, and collapse. Small repeated doses may lead to weakness, general depression, headache, and mental impairment. In addition, there is some implications of increased cancer incidence among those exposed.

Petroleum Hydrocarbons. Petroleum hydrocarbons are a group of compounds that are thick, dark yellow to brown or green-black liquids which consist of a mixture of hydrocarbons from C_2H_2 and up. They are used as a source of gasoline, petro ether, petrolatum, fuel and lubricating oils, butane, and isopropyl alcohol. Gasoline and fuel oil are the two petroleum hydrocarbons of primary concern on in this risk evaluation.

Hydrocarbon-containing petroleum residues are decomposed in soil systems. Hydrocarbons degrade to carbon dioxide and water via several intermediates (organic acids, ketones, aldehydes, alcohols, and other hydrocarbon derivatives). Nonvolatile components of oils tend to stay tightly bound in soil, while volatile fractions may escape into the atmosphere. No significant loss or movement of oil through surface runoff from rainfall or downward leaching occurs.

Gasoline is an aspiration hazard, defats the skin, and has been shown to cause kidney tumors in laboratory animals. It contains benzene and toluene which may be absorbed through the skin. Benzene is cancer hazard that affects the blood. Primary routes of exposure are inhalation and skin contact. Eye contact with liquid gasoline may cause burning, tearing, redness, and transient corneal damage. Prolonged or repeated dermal contact may cause burning, redness, drying and cracking of the skin, and dermatitis. Exposure to mist or excessive vapor

concentration may cause irritation of the nose, throat, and upper respiratory tract. Severe exposures may result in unconsciousness, coma, and death. Ingestion of gasoline may cause signs of central nervous system, depression, headache, nausea, drowsiness, and dizziness.

Fuel oil is a combustible liquid and a skin irritant. Breathing oil mists may irritate the nose and throat. Chronic exposure to oil mists may lead to the development of lipoid pneumonia. Similarly refined and processed petroleum residual materials have been shown to cause skin cancer and liver damage in laboratory animals through prolonged skin contact. There is no direct evidence that fuel oil causes skin cancer or liver damage in humans.

Polynuclear Aromatic Hydrocarbons. PNAs, also termed polycyclic aromatic hydrocarbons (PAHs) are a class of chemical compounds characterized by a basic structure of two or more fused aromatic (benzene) rings. The compounds are fused by pairs of carbon atoms, resulting in a molecule with a carbon atom lying in a single plane with hydrogen atoms. The lowest molecular weight member of this group is naphthalene, with two fused rings. The highest molecular weight member is graphite. PNA compounds can be divided into two groups based on their chemical, physical and biological properties. These two groups are the lower molecular weight (two- to three-ring) compounds and the higher molecular weight (four- to seven-ring) compounds.

The physical properties of PNAs typically vary with increasing molecular weight. Vapor pressure and solubility decrease almost logarithmically with increasing molecular weight. Resistance to reduction and oxidation typically decreases with increasing molecular weight. These trends help to explain why the lower-ring-numbered and higher-ring numbered compounds differ substantially in their behavior and distribution in the environment.

In the case of PNA compounds, the lower-ring-numbered compounds have K_{oc} values in the 10^3 to 10^4 range. The higher-ring-numbered compounds have K_{oc} values from 10^5 to 10^6 . K_{oc} values for PNAs are very high, indicating little tendency for mobility.

PNAs have been noted to be ubiquitous in the environment. In the past, PNA compounds were typically thought to result only from high-temperature pyrolysis of organic materials. Although this is the principal means of PNA generation, it has more recently been shown that low-temperature transformation of sedimentary organic material to form fossil fuels, as well as direct biosynthesis by microbes and plants, are additional sources of PNAs. Anthropogenic sources also increase the loading of PNAs into the environment. This includes industrial activities such as coke and coal gas production, gas production from petroleum, oil refining, and preparation of acetylene from natural gas. Other sources include incineration of domestic and industrial wastes, power generation from fossil fuels, and automobile exhaust.

PNA compounds vary substantially in their acute toxicity to aquatic animals. In general, toxicity to species will increase with increasing molecular weight. However, the higher-ring-numbered PNAs have low acute toxicity, apparently due to their low

solubilities. In most cases, crustaceans are the most sensitive species, polychaete worms are intermediate in sensitivity, and fish are the most resistant. Acute toxicity levels in water are several orders of magnitude higher than levels found in even the most polluted marine and freshwaters. Sediment levels typically approach concentrations similar to the acutely toxic level, however, being bound to the sediment renders PNAs considerably less toxic.

Biodegradation is thought to be the primary fate of PNAs in the environment. Some PNA compounds have been noted to be highly toxic, carcinogenic, mutagenic, and/or teratogenic to many species. PNAs have demonstrated toxicity via the oral and dermal routes, indicating that they are capable of passage across epithelial membranes. Additionally, research indicates that they are easily absorbed through the lungs. They tend to concentrate initially in the liver and kidneys until they are excreted. They eventually move to organs containing or surrounded by fat (e.g., mammary glands, adrenals).

Selenium. Selenium is a naturally-occurring metalloid which may be present in several valence states in the environment. Selenium is associated with sulfide deposits and may be particularly enriched in certain sedimentary deposits. This element is produced as a by-product of copper refining.

Selenium may become mobile in the soil/water system under certain conditions. In aerobic conditions, it may be present in selenite or selenate, both of which are very soluble. Under reducing conditions relatively insoluble metal selenides may also form, limiting mobility. Lack of mobility may be enhanced by sorption on hydrous metal oxides, clays, and organic materials. In reducing conditions, hydrogen selenide can also form, remobilizing sorbed selenium. Mobility is considered to be relatively low in normal acid soils. Biotransformation (methylation) of selenium, or formation of volatile hydrogen selenide by inorganic means under reducing conditions, may cause some volatilization of selenium.

Selenium is generally considered moderately to highly toxic depending on the biotic group. It is highly toxic to aquatic life and animals and poses a serious hazard to cattle in semi-arid regions. Selenium bioaccumulates to high levels in vascular plants without adverse effects. Selenium is an essential trace element for animals but not plants. Selenium does not appear to biomagnify in the food chain. The metabolism and degradation of selenium is influenced by other heavy metals, agricultural chemicals, microorganisms, and physical and chemical factors. Selenium deficiency in animals is considered to be as detrimental as selenium poisoning.

Selenium compounds are readily absorbed from the gastrointestinal tract following oral exposure. Selenium is absorbed by inhalation to some extent. Selenium is an essential element and therefore is nontoxic at doses necessary for normal health and nutrition. However, overexposure to selenium has been associated with adverse health effects. In humans, chronic oral exposure to selenium has been associated with alopecia, dermatitis, discoloration of the skin, loss of fingernails, muscular dysfunction, convulsions, paralysis, amyotrophic lateral sclerosis, nervousness, depression, digestive disturbances, and increased incidences

of dental caries. Headaches and respiratory irritation have been noted in humans following inhalation exposure. Selenium is not known to be a carcinogen. However, certain forms of selenium, such as hydrogen selenide, are considered toxic.

Silver. Silver is a transition metal occurring primarily as a sulfide or in association with other metal sulfides, especially those of lead and copper. Silver is used in manufacturing coinage, tableware, mirrors and jewelry, electroplating, and processing foods. Some silver salts have been used in photography.

Sorption and precipitation processes in natural waters are effective in reducing the concentration of dissolved silver, resulting in higher concentrations in the bed sediments than in the overlying waters. Some silver is also bioaccumulated, and the remainder is transported in solution to the oceans.

Silver is toxic to aquatic bacteria, invertebrates, and fish. Its toxicity ranks second only to mercury among the heavy metals. It is generally not found in high concentrations in aquatic life because most forms of silver are insoluble, and silver has a very short biological half-life.

Exposure to silver does not cause serious toxic manifestations in humans, but prolonged absorption of silver compounds can lead to grayish blue discoloration of skin, known as argyria. Inhalation of dust or fume may cause irritation to the eyes, nose, or throat; leave a metallic taste in the mouth; or result in metal fume fever. Many silver salts are irritating to skin and mucous membranes.

Toluene. Toluene is a monocyclic, aromatic, colorless liquid. It is used in manufacturing benzoic acid, benzaldehyde, explosives, dyes, and many other organic compounds. Toluene functions as a solvent in products such as wood furniture cleaners.

From the available data, it appears that volatilization is the major route of removal from aquatic environments. Once volatilized, atmospheric photodestruction of toluene probably subordinates all other fates. Toluene will be adsorbed by sediments and suspended solids, but the degree to which this adsorption will interfere with volatilization is unknown. Toluene does not bioaccumulate in the environment.

No data are available concerning the chronic toxicity of toluene to freshwater organisms. Toluene is a volatile compound that has been found to readily move from water to the atmosphere. Although its transport and persistence in the environment is not well understood, it is not expected to be bioaccumulated to any great extent.

Little information is available on the toxicity of toluene to terrestrial species. Information on avian toxicity is not available. No information is available on the toxicity of toluene to plants.

Toluene is absorbed in humans following both inhalation and dermal exposure. In humans, the primary acute effects of toluene vapors are central nervous system depression and narcosis. Also seen at low levels of exposure are irritation of the skin and eyes and impairment of coordination and reaction time when inhaled. In

humans, chronic exposure to toluene vapors has been associated with central and peripheral nervous system effects, hepatomegaly, and hepatic and renal function changes.

Xylenes. Xylenes are mixtures of the ortho, meta, and para isomers, with the meta form usually the principal component. Xylenes may also contain 6 to 10 percent impurities such as benzene, ethyl benzene, trimethylbenzene, toluene, phenol, thiophene, pyridene, and nonaromatic hydrocarbons. The xylenes are widely used as fuel components and as solvents for inks, rubbers, gums, resins, adhesives, lacquers, paints, and insecticides. Xylenes are commonly used in the chemical industry as intermediates. Specifically, ortho-xylene is used in the manufacture of phthalic anhydride, which is a basic building block for plasticizers. Meta-xylene is an intermediate in the preparation of isophthalic acid, which is the base of unsaturated polyester resins. Commercially, para-xylene is the most important isomer, most of which converted to terephthalic acid or dimethylterephthalate and used to make fibers, films, and resins.

The primary pathway of concern from soil/water systems is the migration of xylene into ground water used for drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important. Xylenes are relatively mobile in soil/water systems, especially in aqueous phase. Volatilization through air-filled pores is also possible. The chemical is resistant to hydrolysis but is probably biodegradable. Xylenes could persist for months to years (or longer).

The three xylene isomers, compounds having the same chemical constituents in a different configuration, have similar toxicological properties and are discussed together. Approximately 60 percent of an inhaled dose is absorbed, and absorption of orally-administered xylene is nearly complete. Dermal absorption is reported to be minor following exposure to xylene vapor, but may be significant following contact with the liquid. Liquid xylene and high vapor concentrations are irritating to the eyes and the vapor may cause transient, reversible damage to the cornea. Aspiration of liquid into the lungs may cause chemical pneumonitis, pulmonary edema, and hemorrhage. The effects of chronic exposure resemble those from acute exposure, but are more severe.

In humans, acute inhalation exposure to relatively high concentrations of xylenes adversely affects the central nervous system and lungs, and can irritate mucous membranes. Symptoms include dizziness, drowsiness, nausea, vomiting, abdominal pain, loss of appetite, pulmonary edema, and unconsciousness, as well as reversible effects on the liver and kidneys.

Mechanisms of Migration

The media into which chemicals migrate can affect the types of exposures that could occur. For example, a very volatile chemical is likely to be released into air, and thus inhalation exposures may occur. Mechanisms of chemical migration are discussed below to help identify potential exposure pathways.

There are several mechanisms by which chemicals may migrate from source locations at Nebraska ANGB. Contaminated soil, sediment, ground water, and

surface water can act as sources of contaminant migration. Migration of contaminants into the air can occur via fugitive dust emissions and volatilization. Migration into ground water can occur by percolation of rainfall with subsequent leaching and transport. Migration into surface water can occur from surface runoff and ground water discharge. The migration of organic chemicals may be altered by biotransformations which may enhance or inhibit transport. The movement of inorganic compounds is dependent on physical/chemical processes such as pH, ionic charge, and adsorption.

5.2.2.2 Pathways of Exposure

Potential pathways of exposure to chemicals of concern at all six sites at Nebraska ANGB have been summarized in Table 5.2. Demographic and land use information presented in Section 2 was used in developing exposure pathways. The EPA requires that hypothetical future use of a site be considered as well as current use. Therefore, Table 5.2 presents current-use and future-use pathways.

Current-use pathways include exposure to air, ground water, surface water, soils and sediments by base personnel and trespassers. All current-use pathways have little or no probability of completion. While no air quality data was collected, air contamination is expected to be minimal because volatiles were detected only in the ground water at Site 1. Most of the site is vegetated, thus reducing the possibility of fugitive dust generation. The Old Oak Creek channel, Site 2, is the only permanent surface water body at Nebraska ANGB. Access to the ditch is restricted and contact by base personnel is unlikely. No contact with ground water is anticipated since the base potable water supply comes from the City of Lincoln. Contact with contaminated soils and sediments is unlikely for base personnel and not anticipated for trespassers because access to the base is restricted.

Future-use pathways include exposure to contaminated air, ground water, surface water, soils and sediments by hypothetical residents, trespassers, downstream water users, and future hypothetical construction workers. The probability of future-use pathway completion is higher than that for current-use, based primarily on the possibility of the base being developed at some point in the future. Although the base entered into a 100-year lease for the base property, it is remotely possible that the base may be developed for residential use at some point in the future. By the time development might occur on the base, contaminant concentrations will probably have diminished significantly from current levels as a result of natural processes such as attenuation and dispersion.

Similar to current-use pathways, exposure to contaminants through volatilization and fugitive dust generation is expected to be minimal. Exposure to contaminated ground water through its development as a potable drinking water source is unlikely because future residents, if any, would probably be supplied with water by the City of Lincoln. Exposure to contaminated surface water through contact with water in the drainage ditch and through surface water entering downstream drinking water sources are other future-use pathways. Exposure of hypothetical residents and trespassers to contamination in soils and sediments is unlikely unless access to the base becomes less restricted. Exposure to contamination in soils is slightly more

TABLE 5.2
MATRIX OF POTENTIAL EXPOSURE PATHWAYS
155th AIR REFUELING GROUP
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Transport Medium | Release Source and Mechanism | Primary Exposure Point | Potential Receptors | Primary Exposure Route | Probability of Pathway Completion |
|---------------------|--|---|--|--|---|
| <u>CURRENT USE</u> | | | | | |
| Air | Affected soils/
Fugitive dust generation,
volatilization | Nebraska ANG B and areas downwind | Base personnel,
Trespassers | Inhalation,
Dermal | Low: Primary identified sources of contamination are associated with ground water. No volatiles were detected in surface water, or soil. Most of the site is covered with vegetation so it is unlikely that contaminants would become airborne. |
| Ground Water | Affected soils,
ground water/Site leaching | None – no current ground water use | Base personnel | Ingestion,
Inhalation,
Dermal | None: Base served by city water. |
| Surface Water | Affected soils, ground water/Seepage of ground water, surface runoff | Surface runoff and Old Oak Creek | Base personnel | Ingestion,
Dermal | Low: Surface runoff occurs only after a heavy rainfall. Workers unlikely to intentionally walk through Old Oak Creek. |
| Soils/
Sediments | Affected soils,
sediments, surface water and ground water/Site leaching, runoff, tracking | Surface soils and Old Oak creek sediments | Trespassers,

Base personnel

Trespassers,
Children | Ingestion,
Dermal

Ingestion,
Dermal

Ingestion,
Dermal | None: Access to the site is restricted.

Low: Incidental contact with soils or sediment would be infrequent.

None: Access to the site is restricted. |

TABLE 5.2 (Continued)
 MATRIX OF POTENTIAL EXPOSURE PATHWAYS
 155th AIR REFUELING GROUP
 LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Transport Medium | Release Source and Mechanism | Primary Exposure Point | Potential Receptors | Primary Exposure Route | Probability of Pathway Completion |
|-------------------|---|--|---|-------------------------------------|---|
| <u>FUTURE USE</u> | | | | | |
| Air | Affected soils/
Fugitive dust generation,
volatilization | Nebraska ANGB
and areas downwind | Base personnel,
Trespassers | Inhalation,
Dermal | Low: Primary identified sources of contamination are associated with ground water. No volatiles were detected in surface water, or soil. Most of the site is covered with vegetation so it is unlikely that contaminants would become airborne. |
| Ground Water | Affected soils,
ground water/Site leaching | Hypothetical future
onsite wells | Hypothetical
residents | Ingestion,
Inhalation,
Dermal | Low: Would not be likely to occur unless the base is sold. |
| Surface Water | Affected soils,
outfalls, ground water/
Surface runoff, ground
water seepage | Surface runoff
and Old Oak Creek | Hypothetical
residents,
Trespassers | Ingestion,
Inhalation,
Dermal | Low: Unlikely that base would be developed or become unrestricted, so that residents would have recreational use of the channel. |
| | Surface runoff | Surface water
entering down-
stream drinking
water source | Downstream water
users | Ingestion,
Inhalation,
Dermal | Low: Unlikely that runoff would enter drinking water source unless dramatic change in climate or drainage patterns occurred. |

TABLE 5.2 (Continued)
MATRIX OF POTENTIAL EXPOSURE PATHWAYS
155th AIR REFUELING GROUP
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Transport Medium | Release Source and Mechanism | Primary Exposure Point | Potential Receptors | Primary Exposure Route | Probability of Pathway Completion |
|-------------------|---|-------------------------------------|--|-------------------------------|---|
| Soil/
Sediment | Affected soils, sediments, surface water and ground water/Site leaching, runoff, tracking | Soils at the site and Old Oak Creek | Hypothetical residents | Ingestion, Inhalation, Dermal | Low: Contact unlikely unless base is sold. |
| | | | Trespassers | Ingestion, Inhalation, Dermal | Low: Contact unlikely unless access to base becomes less restricted. |
| | | | Future Hypothetical Construction Workers | Ingestion, Inhalation, Dermal | Moderate: Future construction in contaminated areas is not planned but is possible. |

likely for future construction workers because construction activities may occur even if the base is not sold.

5.2.3 Toxicity Assessment

The objective of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. The types of toxicity information considered in this assessment include the slope factor to evaluate carcinogenic potential and the reference dose (RfD) used to evaluate noncarcinogenic effects.

5.2.3.1 Health Criteria for Carcinogenic Effects

For chemicals that exhibit carcinogenic effects, most authorities recognize that one or more molecular events can evoke changes in a single cell or a small number of cells that can lead to tumor formation. This is the nonthreshold theory of carcinogenesis which purports that any level of exposure to a carcinogen can result in some finite possibility of generating the disease. Generally, regulatory agencies assume the non-threshold hypothesis for carcinogens in the absence of information concerning the mechanisms of action for the chemical (U.S. Environmental Protection Agency 1986b).

EPA's Carcinogen Assessment Group (CAG) has developed slope factors (i.e., dose-response values) for estimating excess lifetime cancer risks associated with various levels of lifetime exposure to potential human carcinogens. The carcinogenic slope factors can be used to estimate the lifetime excess cancer risk associated with exposure to a potential carcinogen. Risks estimated using slope factors are considered unlikely to underestimate actual risks, but they may overestimate actual risks. Excess lifetime cancer risks are generally expressed in scientific notation and are probabilities. An excess lifetime cancer risk of 1×10^{-6} (one in one million), for example, represents the probability that an individual will develop cancer as a result of exposure to a carcinogenic chemical over a 70-year lifetime under specified exposure conditions. EPA has suggested developing remedial alternatives for cleanup of Superfund sites using total excess lifetime cancer risks ranging from 10^{-4} (one in ten thousand) to 10^{-6} .

In practice, slope factors are derived from the results of human epidemiology studies or chronic animal bioassays. The data from animal studies are fitted to the linearized multistage model and dose-response curve is obtained. The 95th percentile upper confidence limit slope of the dose-response curve is subjected to various adjustments and an interspecies scaling factor is applied to conservatively derive the slope factor for humans. Thus, the actual risks associated with exposure to a potential carcinogen quantitatively evaluated based on animal data are not likely to exceed the risks estimated using these slope factors, but they may be much lower. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an ad hoc basis. These models provide rough but plausible estimates of the upper limits on lifetime risk. Slope factors based on human epidemiological data are also derived using very conservative assumptions

and, as such, they too are considered unlikely to underestimate risks. In summary, while the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using a slope factor, they could be considerably lower.

In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical. EPA has proposed a system for characterizing the overall weight of evidence for a chemical's carcinogenicity based on the availability of animal, human, and other supportive data (U.S. Environmental Protection Agency, 1986b). The weight-of-evidence classification is an attempt to determine the likelihood that an agent is a human carcinogen and thus qualitatively affects the estimation of potential health risks. Three major factors are considered in characterizing the overall weight of evidence for carcinogenicity: (1) the quality of evidence from human studies and (2) the quality of evidence from animal studies, which are combined into a characterization of the overall weight of evidence for human carcinogenicity; and (3) other supportive information which is assessed to determine whether the overall weight of evidence should be modified. EPA's final classification of the overall weight of evidence includes the following five categories:

Group A - - Human Carcinogen

This category indicates that there is sufficient evidence from epidemiological studies to support a casual association between an agent and cancer.

Group B - - Probable Human Carcinogen

This category generally indicates that there is at least limited evidence from epidemiological studies of carcinogenicity to humans (Group B1) or that, in the absence of adequate data on humans, there is sufficient evidence of carcinogenicity in animals (Group B2).

Group C - - Possible Human Carcinogen

This category indicates that there is limited evidence of carcinogenicity in animals in the absence of data on humans.

Group D - - Not Classified

This category indicates that the evidence for carcinogenicity in animals is inadequate.

Group E - - No evidence of Carcinogenicity to Humans

This category indicates that there is no evidence for carcinogenicity in at least two adequate animal tests in different species, or in both epidemiological and animal studies.

Slope factors are developed based on epidemiological or animal bioassay data for a specific route of exposure, either oral or inhalation. For some chemicals, sufficient data are available to develop route-specific slope factors for inhalation and ingestion. For chemicals with only one route-specific slope factor but for which carcinogenic effects may also occur via another route, the available value may be used to evaluate risks associated with both potential routes of exposure.

Several of the selected chemicals of concern have been classified as potential carcinogens by EPA, and each of these has also been assigned a carcinogenicity weight-of-evidence category (Table 5.3). Some of these chemicals are:

Group A - - Human Carcinogens

Arsenic

Benzene

Chromium (VI)

Group B - - Probable Human Carcinogens

Benzo(a)anthracene

Benzo(a)pyrene

Benzo(b)fluoranthene

Benzo(k)fluoranthene

Bis(2-ethylhexyl) phthalate

Cadmium

Chrysene

Lead

Group C - - Possible Human Carcinogens

None

Potential carcinogenic effects and slope factors for chemicals of concern identified at Nebraska ANGB are shown in Table 5.3.

5.2.3.2 Health Criteria for Noncarcinogenic Effects

For chemicals that exhibit noncarcinogenic (e.g., systemic) effects, many authorities consider organisms to have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the health effect is manifested. For example, an organ can have a large number of cells performing the same or similar functions that must be significantly depleted before the effect on the organ is seen. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects.

Health criteria for chemicals exhibiting noncarcinogenic effects for use in risk assessment are generally developed using EPA RfDs developed by the RfD Work Group (U.S. Environmental Protection Agency, 1987b). For those chemicals for which EPA has not derived verified RfDs, health criteria used in a risk assessment may be derived from information provided in EPA documents. In general, the RfD is an estimate of an average daily exposure to an individual (including sensitive individuals) below which there will not be an appreciable risk of adverse health

TABLE 5.3
TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical | Slope Factor 1/(mg/Kg/day)a/ | | Weight - of - Evidence Classification b/ | | Type of Cancer | |
|----------------------------|------------------------------|----------|--|------|-------------------|----------|
| | Inhalation | Oral | Inhalation | Oral | Inhalation | Oral |
| Arsenic | 5.00E+01 | 1.75E+00 | A | A | respiratory tract | skin |
| Barium | See Table 5.4 | | | | | |
| Benzene | 2.90E-02 | 2.90E-02 | A | A | leukemia | leukemia |
| Benzo(a)anthracene | NA c/ | ND d/ | B2 | B2 | | |
| Benzo(a)pyrene | ND | ND | B2 | B2 | respiratory tract | stomach |
| Benzo(b)fluoranthene | ND | ND | B2 | B2 | NA | NA |
| Benzo(k)fluoranthene | ND | ND | B2 | B2 | NA | NA |
| Bis(2-ethylhexyl)phthalate | ND | 1.40E-02 | B2 | B2 | NA | liver |
| Cadmium | 6.10E+00 | NA | B1 | ND | respiratory tract | NA |
| Chromium (VI) | 4.10E+01 | ND | A | ND | lung | NA |
| Chrysene | ND | NA | B2 | B2 | NA | NA |
| Ethyl benzene | See Table 5.4 | | | | | |
| Fluoranthene | See Table 5.4 | | | | | |
| Fluoride | See Table 5.4 | | | | | |
| Lead | ND | ND | B2 | B2 | liver | liver |
| Mercury | See Table 5.4 | | | | | |

TABLE 5.3 (Continued)
 TOXICITY VALUES: POTENTIAL CARCINOGENIC EFFECTS
 155th AIR REFUELING GROUP
 NEBRASKA AIR NATIONAL GUARD
 LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical | Slope factor 1/(mg/kg-day) a/ | | Weight-of - Evidence Classification b/ | | Type of Cancer | |
|--------------|-------------------------------|------|--|------|----------------|------|
| | Inhalation | Oral | Inhalation | Oral | Inhalation | Oral |
| Nitrate | See Table 5.4 | | | | | |
| Phenanthrene | See Table 5.4 | | | | | |
| Pyrene | See Table 5.4 | | | | | |
| Selenium | See Table 5.4 | | | | | |
| Silver | See Table 5.4 | | | | | |
| Toluene | See Table 5.4 | | | | | |
| TPH | See Table 5.4 | | | | | |
| Xylenes | See Table 5.4 | | | | | |

a/ mg/Kg/day = milligram per kilogram per day.

b/ A = Human Carcinogen; B = Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); C = Possible Human Carcinogen.

c/ NA = Not Applicable or Not Available

d/ ND = Not Determined

Source: U.S. Environmental Protection Agency, 1989a and 1990.

effects. The RfD is derived using conservative safety factors (e.g., to adjust from animals to humans and to protect sensitive subpopulations) to ensure that it is unlikely to underestimate the potential for adverse noncarcinogenic effects to occur. The purpose of the RfD is to provide a benchmark against which the sum of other doses (e.g., those projected from human exposure to various environmental conditions) might be compared. Doses that are significantly higher than the RfD may indicate an inadequate margin of safety could exist for exposure to that substance and that an adverse health effect could occur.

EPA has developed RfDs for many of the chemicals of concern selected for Nebraska ANGB. In addition, the chemicals of concern may affect different target organs in the body. Some of the chemicals of concern that may have noncarcinogenic effects following long-term exposure, and the target organs that are most sensitive to these chemicals, are as follow:

Chemicals That May Adversely Affect The Liver

- Bis(2-Ethylhexyl) phthalate

- Chromium (III)

- Ethyl benzene

- Lead

Chemicals That May Adversely Affect the Liver and Kidney

- Cadmium

- Ethyl benzene

- Mercury

- Pyrene

Chemicals That May Adversely Affect the Nervous System

- Lead

- Mercury

- Toluene

Chemicals That May Adversely Affect Other Systems

- Arsenic may cause keratosis.

- Barium may cause cardiovascular effects.

- Chromium(III) may cause reductions in organ weight.

- Fluoride may cause weight loss or mottling of teeth.

- Selenium may cause dermatitis and gastrointestinal disturbances.

- Silver may cause skin discoloration or irritation of mucous membranes.

- Total xylenes may cause reproductive effects.

- Nitrate may cause methemoglobinemia.

Potential noncarcinogenic effects with RfDs of chemicals of concern identified at Nebraska ANGB are shown on Table 5.4.

No RfDs or slope factors are available for the dermal route of exposure. In some cases, however, noncarcinogenic or carcinogenic risks associated with dermal exposure can be evaluated using an oral RfD or an oral slope factor. Exposures via the dermal route generally are calculated and expressed as absorbed doses. These absorbed doses are compared to an oral toxicity value that is also expressed as an absorbed dose. This comparison is only appropriate for chemicals causing effects through a systemic action. At this time toxicity information expressed as an absorbed dose is not available.

5.2.4 Risk Screening

5.2.4.1 Health and Environmental Criteria

In this section concentrations of chemicals of concern are compared with appropriate criteria to provide a rough estimation as to whether the contaminants pose a risk. The method is intended as a preliminary screening tool rather than a detailed evaluation of risks posed by contaminants at the site. For clarity, each of the six sites is evaluated separately.

Maximum concentrations of chemicals at each of the six sites at Lincoln ANGB were compared to health and environmental criteria. Health and environmental criteria may consist of applicable or relevant and appropriate requirements (ARARs), EPA-established exposure-limit criteria (e.g., slope factors and RfDs), or other standards, guidelines, and toxic threshold values.

Maximum chemical concentrations were first compared to ARARs. Section 121 of SARA establishes cleanup criteria for Superfund sites. This section of the statute sets forth the need for appropriate remedial actions, consistent with the NCP, that provide a cost-effective response. Subsection (d) of Section 121 generally requires that remedial actions attain a level of standard of control at least equivalent to ARARs promulgated under federal or state laws. "Applicable standards" are those cleanup or control standards and other substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state law which specifically address a hazardous substance, pollutant, contaminant, remedial action location, or other circumstance at a CERCLA site. "Relevant or appropriate standards" refer to those cleanup or control standards, and other substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state law that, while not "applicable", address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site. EPA has identified three categories of ARARs:

- . Chemical Specific;
- . Location Specific (e.g., wetland limitations or historical sites); and
- . Action Specific (e.g., performance and design standards).

In performing this preliminary risk evaluation, chemical-specific ARARs were considered. ARARs are presented in Table 5.5.

TABLE 5.4
TOXICITY VALUES: POTENTIAL NONCARCINOGENIC EFFECTS
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| CHEMICAL | <u>CHRONIC RfD (mg/Kg/day)a/</u> | | <u>CRITICAL EFFECT</u> |
|----------------------------|----------------------------------|----------|--|
| | INHALATION | ORAL | |
| Arsenic | ND b/ | 1.00E-03 | Cancer c/ |
| Barium | 1.00E-04 | 7.00E-02 | keratosis and hyperpigmentation; cancer c/
increased blood pressure |
| Benzene | See Table 5.3 | | |
| Benzo(a)anthracene | See Table 5.3 | | |
| Benzo(a)pyrene | See Table 5.3 | | |
| Benzo(b)fluoranthene | See Table 5.3 | | |
| Benzo(k)fluoranthene | See Table 5.3 | | |
| Bis(2-ethylhexyl)phthalate | ND | 2.00E-02 | increased relative liver weight; cancer b/ |
| Cadmium | ND | 5.00E-04 | renal damage |
| Chromium (III) | ND | 1.00E+00 | hepatotoxicity |
| Chromium (IV) | ND | 5.00E-03 | not defined |
| Chrysene | See Table 5.3 | | |
| Ethyl benzene | ND | 1.00E-01 | hepatotoxicity
and nephrotoxicity |
| Fluoranthene | Data Inadequate | | |
| Fluoride | ND | 6.00E-02 | dental fluorosis |

TABLE 5.4 (Continued)
TOXICITY VALUES: POTENTIAL NONCARCINOGENIC EFFECTS
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| CHEMICAL | CHRONIC RfD (mg/Kg/day) ^{a/} | | CRITICAL EFFECT | |
|------------------------------|---------------------------------------|----------|--|--|
| | INHALATION | ORAL | INHALATION | ORAL |
| Lead | ND | ND | hepatopoietic and CNS f/
effects; cancer c/ | hepatopoietic and CNS
effects; cancer b/ |
| Mercury | ND | 3.00E-04 | NA | kidney effects, CNS effects |
| Nitrate | Data Inadequate | | NA | methemoglobinemia |
| Phenanthrene | Data Inadequate | | | |
| Pyrene | ND | 3.00E-02 | NA | renal effects |
| Selenium | ND | 3.00E-03 | ND | hair and nail loss, dermatitis |
| Silver | ND | 3.00E-03 | irritation of
mucous membranes | irritation of
mucous membranes |
| Toluene | 2.00E+00 | 3.00E-01 | CNS effects | eyes and nose irritation; CNS effects |
| Xylenes | 9.00E-02 | 2.00E+00 | CNS effects, nose
and throat irritation | hyperactivity, decreased body weight and
weight and increased mortality
at higher dosage |
| Total Petroleum Hydrocarbons | Data Inadequate | | | |

a/ Rfd = reference dose; mg/Kg/day = milligrams per kilogram per day.

b/ ND=Not Determined

c/ See Table 5.3

d/ Value withdrawn from IRIS

e/ NA=Not Applicable or not available

f/ CNS=Central Nervous System

Source: U.S. Environmental Protection Agency, 1989a and 1990.

TABLE 5.5
 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
 AND OTHER CRITERIA FOR THE PROTECTION OF HUMAN HEALTH^{a/}
 155TH AIR REFUELING GROUP
 NEBRASKA AIR NATIONAL GUARD
 LINCOLN MUNICIPAL AIRPORT
 LINCOLN, NEBRASKA

| | Safe Drinking
Water Act
Maximum
Contaminant Level ^{b/}
(mg/L) ^{e/} | State of
Nebraska
Maximum
Contaminant Level ^{c/}
(mg/L) | EPA Ambient
Water Quality
Criteria for
Drinking Water ^{d/} | Other
Criteria |
|------------------------------|--|--|--|-------------------------------|
| Arsenic | 0.05 | 0.05 | 25 ng/L ^{e/} | 0.1-40 mg/Kg ^{fl} |
| Barium | 1.0 | 1 | -- | 100-3500 mg/Kg ^{fl} |
| Benzene | 0.005 | 0.005 | 0(670 ng/L) | -- |
| Benzo(a) anthracene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Benzo(b) fluoranthene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Benzo(k) fluoranthene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Benzo(a) pyrene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Bis (2-ethylhexyl) phthalate | -- | -- | -- | -- |
| Cadmium | 0.01 | 0.010 | 0.010 mg/L | 0.01-7.0 mg/Kg ^{fl} |
| Chromium | 0.05 | 0.05 | 0.050 mg/L ^{j/} | 5.0-3,000 mg/Kg ^{fl} |
| Chrysene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Ethyl benzene | 0.7 ^{j/} | -- | 2.4 mg/L | -- |
| Fluoranthene | -- | -- | 0.188 mg/L | 100 mg/Kg ^{h/} |
| Fluoride | 1.4 to 2.4 | 4.0 | -- | -- |
| Lead | 0.05 | 0.05 | 0.050 mg/L | 500 mg/Kg ^{k/} |
| Mercury | 0.002 | 0.002 | 0.010 mg/L | 0.01-0.8 mg/Kg ^{fl} |
| Nitrate | 10 | 10 | -- | -- |
| Phenanthrene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Pyrene | -- | -- | 0(3.1 ng/L) ^{g/} | 100 mg/Kg ^{h/} |
| Selenium | 0.01 | 0.01 | 0.010 mg/L | 0.1-2.0 ^{fl} |
| Silver | 0.05 | 0.05 | 0.050 mg/L | 0.1-5.0 mg/Kg ^{fl} |
| Toluene | 2 ^{j/} | -- | 15 mg/L | -- |
| Xylenes | 10 ^{j/} | -- | -- | -- |

TABLE 5.5 (Continued)
 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
 AND OTHER CRITERIA FOR THE PROTECTION OF HUMAN HEALTH
 155TH AIR REFUELING GROUP
 NEBRASKA AIR NATIONAL GUARD
 LINCOLN MUNICIPAL AIRPORT
 LINCOLN, NEBRASKA

| | |
|----|--|
| a/ | See Table 5.20 for environmental criteria. |
| b/ | Source: U.S. Environmental Protection Agency (1989c and 1987a). |
| c/ | Source: Nebraska Department of Environmental Control (1988a). |
| d/ | Source: U.S. Environmental Protection Agency (1986c). |
| e/ | mg/L = milligrams per liter; ng/L = nanograms per liter. |
| f/ | Normal range in background soils as reported by Dragun (1988). |
| g/ | Value for total polynuclear aromatic hydrocarbons (PNAs). |
| h/ | Total PNAs recommended by the Agency for Toxic Substance and Disease Registry (ATSDR). |
| i/ | Criteria for Chromium VI. Criteria for Chromium III is 179 mg/L. |
| j/ | Proposed MCL. |
| k/ | Target concentration for soils from preliminary modeling by U.S. Environmental Protection Agency (1989b). Natural background concentrations range from 2-200 mg/Kg (Dragun, 1988). |

At the present time, EPA considers drinking water maximum contaminant levels (MCLs), federal ambient water quality criteria (WQC), national ambient air quality standards (NAAQS), and promulgated state environmental standards to be ARARs. WQC may be considered ARARs for ground water only if they reflect current scientific information and there are no federal MCLs or state ARARs.

The Nebraska Department of Environmental Control (1988a) has promulgated ground water quality standards. Numerical standards for point-source pollution correspond to the State of Nebraska MCLs and are listed in Table 5.5. The policy of the state is to protect and improve the quality of ground water for beneficial uses. However, in determining whether the water quality standards are attainable, the state considers environmental, technological, social, and economic factors. The state's ground water remedial action protocol generally requires removal of free product as a minimum cleanup action.

Since not all chemicals have ARARs, Table 5.5 also lists other criteria for comparison. Other criteria include average background concentrations of metals in soils, and EPA preliminary guidelines for lead and PNAs in soils. Where ARARs are not developed, other information may be needed to determine what is protective of human health and the environment. Other criteria to be used for comparison purposes include health-based levels derived from toxicity data.

Current information on the health and environmental effects of various toxicants, including slope factors and RfDs were obtained from the Integrated Risk Information System (IRIS) (U.S. Environmental Protection Agency, 1989a). IRIS is a computerized library of current information that is up-dated on a continuous basis. It contains health risk assessment information on chemicals that have undergone a detailed review of toxicity data by work groups composed of EPA scientists from several agency program offices, and represents an EPA consensus. Information includes slope factors and RfDs for systemic toxicants. These values are used to calculate human health-based criteria according to EPA guidelines.

As previously described, human health-based criteria for carcinogens represent an upper bound estimate of the average daily dose of a carcinogenic substance that corresponds to a specified excess cancer risk for lifetime exposure. The criteria were calculated from slope factors (Table 5.3) in the following manner:

$$C_i = (R/q1^*) \times (W/I)$$

where

C_i = the criterion concentration for the constituent of interest;

R = the specified risk level (e.g., 10^{-6} for Class A and Class B carcinogens, 10^{-5} for Class C carcinogens);

$q1^*$ = the carcinogenic slope factor in $(\text{mg/kg/day})^{-1}$ developed by the EPA, Office of Health and Environmental Assessment, or EPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup;

W = the assumed weight of the exposed individual; and

I = the intake amount for a given time period.

In calculating the carcinogen criteria for soil ingestion, the assumed I for soil is 0.1 gram per day (g/day) for a 70-Kg person. When ground water or surface water was the medium of concern the carcinogen criteria for water were used unless MCLs existed. The assumed I for water ingestion is 2 liters per day (L/day) for a 70-Kg person. Criteria for the inhalation pathway were not calculated because no air monitoring data was collected. There is currently no toxicity data available to address the dermal route of exposure.

Human health-based criteria for (i.e., noncarcinogenic) toxicants are an estimate of the daily exposure an individual (including sensitive individuals) can experience without appreciable risk of health effects during a lifetime, and are based on EPA-derived RfDs (Table 5.4).

For water ingestion, the systemic criteria are calculated for a 70-Kg adult ingesting 2 L/day over a chronic lifetime exposure period (i.e., 70 years). For soil ingestion, the assumed intake rate of 0.2 g/day is based on a 5-year exposure period for a 16-Kg child. These exposure assumptions for soil are reflective of an average scenario in which children ages one to six (who exhibit the greatest tendency to ingest soil) are assumed to ingest an average amount of soil on a daily basis. Soil ingestion rates for adults were not included because adults generally do not ingest large amounts of soil. Criteria for the inhalation pathway were not calculated because no air monitoring data was collected. Human health-based criteria were calculated for the selected exposure routes, as shown in the following equation:

$$C_i = (RfD) \times (W/I)$$

where

C_i = Criterion concentration for constituent of interest;

RfD = Reference Dose developed by EPA;

W = the assumed weight of the exposed individual; and

I = the intake amount for a given time period.

The systemic criteria for the water (ingestion) route of exposure should be used unless MCLs exist. For other routes of exposure (e.g., soil ingestion), carcinogen criteria should be used unless lower systemic criteria exist. Where toxicants are both carcinogenic and systemically toxic, the lower of the two values was used for human health assessment.

5.2.4.2 Site 1

At Site 1, ingestion of ground water was the only pathway of exposure quantitatively addressed. Benzene, nitrate, and selenium were all shown to exceed their respective MCLs of 0.005 mg/L, 10 mg/L, and 0.01 mg/L (Table 5.6). Although benzene's presence may be the result of contamination from the base, the State of Nebraska Department of Environmental Control has indicated that concentrations of nitrate found in ground water at the base are similar to concentrations found throughout the state (Chambers, 1989). The selenium in the ground water probably derives from the soil where it occurs naturally. The geometric mean of selenium concentrations in eastern and western United States

TABLE 5.6
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 1
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/L) ^{b/} | Criterion Type Used ^{a/} | Criterion Value (mg/L) | Releasing Unit Medium Site 1 |
|-----------------|---------------------|--|-----------------------------------|------------------------|-----------------------------------|
| | | | | | Ground Water |
| GROUND | Arsenic | 4.80E-02 | MCL | 5.00E-02 | NO |
| WATER | Barium | 4.28E-01 | MCL | 1.00E+00 | NO |
| (Ingestion) | Benzene | 6.10E-01 | MCL | 5.00E-03 | YES |
| | Ethyl benzene | 1.10E+00 | RfD | 4.00E+00 | NO |
| | Fluoride | 1.03E+00 | MCL | 4.00E+00 | NO |
| | Nitrate | 1.92E+01 | MCL | 1.00E+01 | YES |
| | Selenium | 1.70E-02 | MCL | 1.00E-02 | YES |
| | Toluene | 4.20E-02 | RfD | 1.00E+01 | NO |
| | TPH ^{c/} | 9.14E+01 | - | - | - |
| | Xylenes | 4.60E+00 | RfD | 7.00E+01 | NO |

a/ MCL = maximum contaminant level; RfD = reference dose.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

soils reported by Shacklette and Boerngen (1984) was 0.30 and 0.23 mg/Kg, respectively (Table 4.6). Selenium concentrations in excess of 0.5 mg/Kg were detected in eastern Nebraska and western Iowa (Shacklette and Boerngen, 1984).

Because three chemicals of concern exceed their respective MCL's at Site 1, there is a potential public health concern, although the likelihood of pathway completion is small.

5.2.4.3 Site 2

Site 2 surface water, ground water, and sediments were sampled. No chemicals of concern exceeded criteria values in surface water (Table 5.7). In ground water only nitrate exceeded its MCL of 10 mg/L (Table 5.8). As stated previously, the nitrate concentrations are similar to those found elsewhere in the state. In sediments, only arsenic was found to exceed its criteria (Table 5.9). Arsenic is not associated with any identified sources of contaminants at the base, and levels are within average concentrations reported for the eastern and western United States (Table 4.6). Soil arsenic levels in eastern Nebraska and western Iowa ranged up to at least 10 mg/kg (Shacklette et al., 1974; Shacklette and Boerngen, 1984).

Because only two chemicals of concern exceeded criteria in the three media sampled at Site 2, and they are not thought to be associated with site contamination, the site probably does not pose a current potential public health concern. Due to its close proximity to Site 1, however, concentrations of chemicals of concern at Site 2 could increase to the level at which they would pose a potential health concern in the future.

5.2.4.4 Site 3

Ground water and soils were sampled at Site 3. Soils data were divided into surface soils (less than 1 foot deep) and subsurface soils (greater than 1 foot deep). Analysis of soils data was done in this way to correspond to likely pathways of exposure. Only potential future construction workers would be exposed to subsurface soils, while all other receptors would be exposed only to surface soils (Table 5.2).

In ground water, no criteria were exceeded (Table 5.10). In both surface and subsurface soils only arsenic exceeded its criteria (Tables 5.11 and 5.12). Because arsenic is not associated with any identified sources of contamination and was not an outlier in the statistical analysis, concentrations are interpreted to represent baseline conditions. In addition, detected arsenic concentrations are similar to those reported for the region (Table 4.6 and Section 5.2.4.3). Therefore, Site 3 does not appear to pose a significant public health concern.

5.2.4.5 Site 4

Only soils were sampled at Site 4. As with Site 3, the soils data were divided into surface and subsurface soils for analysis to accommodate exposure pathways. Only arsenic exceeded its criteria, both in surface and subsurface soils (Tables 5.13 and 5.14). A statistical analysis showed that the highest arsenic value in surface soils was an outlier and, therefore, may be higher than baseline conditions. However, the

TABLE 5.7
COMPARISON OF SURFACE WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 2
155th AIR REFUELING GROUP
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 2
Medium Surface Water

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Criterion Type Used a/ | Criterion Value (mg/L) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|--|------------------------|------------------------|---|
| SURFACE | Arsenic | 1.70E-02 | MCL | 5.00E-02 | NO |
| WATER | Barium | 1.41E-01 | MCL | 1.00E+00 | NO |
| (Ingestion) | Fluoride | 1.19E+00 | MCL | 4.00E+00 | NO |
| | Nitrate | 2.70E+00 | MCL | 1.00E+01 | NO |
| | Selenium | 5.00E-03 | MCL | 1.00E-02 | NO |
| | TPH c/ | 1.60E+00 | - | - | - |

a/ MCL = maximum contaminant level.

b/ mg/L = milligrams per liter.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.8
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 2
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 2
Medium Ground Water

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Criterion Type Used a/ | Criterion Value (mg/L) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|--|------------------------|------------------------|---|
| GROUND | Arsenic | 4.00E-03 | MCL | 5.00E-02 | NO |
| WATER | Barium | 1.97E-01 | MCL | 1.00E+00 | NO |
| (Ingestion) | Chromium | 3.00E-03 | MCL | 5.00E-02 | NO |
| | Fluoride | 5.20E-01 | MCL | 4.00E+00 | NO |
| | Nitrate | 1.82E+01 | MCL | 1.00E+01 | YES |
| | TPH c/ | 1.80E+00 | - | - | - |

a/ MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.9
COMPARISON OF SEDIMENTS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 2
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Exposure
Medium | Chemical of
Concern | Maximum
Release
Concentration
(mg/Kg)b/ | Criterion
Type Used a/ | Criterion
Value
(mg/Kg) | Releasing Unit Site 2
Medium Sediment |
|--------------------|-----------------------------|--|---------------------------|-------------------------------|---|
| | | | | | Release
Concentrations
Exceed Criterion ? |
| SEDIMENT | Arsenic | 5.10E+00 | SF | 4.00E-01 | YES |
| (Ingestion) | Barium | 1.28E+02 | RfD | 4.00E+03 | NO |
| | Benzo(a)anthracene | 9.00E-01 | - | - | - |
| | Benzo(a)pyrene | 8.40E-01 | - | - | - |
| | Benzo(b)fluoranthene | 1.10E+00 | - | - | - |
| | Benzo(k)fluoranthene | 8.90E-01 | - | - | - |
| | Bis(2-ethylhexyl) Phthalate | 2.50E+00 | SF | 5.00E+01 | NO |
| | Cadmium | 3.70E+00 | RfD | 4.00E+01 | NO |
| | Chromium | 2.90E+01 | RfD | 4.00E+02 | NO |
| | Chrysene | 1.30E+00 | - | - | - |
| | Fluoranthene | 2.80E+00 | - | - | - |
| | Fluoride | 7.50E+01 | RfD | 4.80E+03 | NO |
| | Lead | 9.20E+01 | - | - | - |
| | Mercury | 8.90E-02 | RfD | 2.40E+01 | NO |
| | Phenanthrene | 2.50E+00 | - | - | - |
| | Pyrene | 2.30E+00 | RfD | 4.80E+00 | NO |
| | Selenium | 4.00E-01 | RfD | 2.40E+02 | NO |
| | Silver | 2.70E+00 | RfD | 2.40E+02 | NO |
| | Toluene | 4.50E-02 | RfD | 2.40E+04 | NO |
| | TPH c/ | 2.91E+03 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.10
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Exposure
Medium | Chemical of
Concern | Maximum
Release
Concentration
(mg/L)b/ | Criterion
Type Used a/ | Criterion
Value
(mg/L) | Releasing Unit Site 3 |
|--------------------|------------------------|---|---------------------------|------------------------------|--------------------------|
| | | | | | Medium Ground Water |
| GROUND | Arsenic | 4.00E-03 | MCL | 5.00E-02 | NO |
| WATER | Barium | 3.09E-01 | MCL | 1.00E+00 | NO |
| (Ingestion) | Chromium | 5.00E-03 | MCL | 5.00E-02 | NO |
| | Fluoride | 7.30E-01 | MCL | 4.00E+00 | NO |
| | Nitrate | 5.10E+00 | MCL | 1.00E+01 | NO |
| | Selenium | 1.00E-02 | MCL | 1.00E-02 | NO |

a/ MCL = maximum contaminant level.

b/ mg/L = milligrams per liter.

TABLE 5.11
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 3
Medium Surface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SURFACE | Arsenic | 5.80E+00 | SF | 4.00E-01 | YES |
| SOILS | Barium | 2.04E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 9.00E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.50E+01 | RfD | 4.00E+02 | NO |
| | Fluoride | 7.39E+01 | RfD | 4.80E+03 | NO |
| | Lead | 8.10E+01 | - | - | - |
| | Mercury | 3.90E-02 | RfD | 2.40E+01 | NO |
| | Nitrate | 9.87E+02 | RfD | 8.00E+05 | NO |
| | Selenium | 3.00E-01 | RfD | 2.40E+02 | NO |
| | Silver | 2.00E-01 | RfD | 2.40E+02 | NO |
| | TPH c/ | 8.71E+01 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.12
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 3
Medium Subsurface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------------------|---------------------|---|------------------------|-------------------------|---|
| SUBSURFACE SOILS
(Ingestion) | Arsenic | 4.80E+00 | SF | 4.00E-01 | YES |
| | Barium | 2.16E+02 | RfD | 4.00E+03 | NO |
| | Cadmium | 4.00E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.70E+01 | RfD | 4.00E+02 | NO |
| | Fluoride | 1.37E+02 | RfD | 4.80E+03 | NO |
| | Lead | 7.20E+00 | - | - | - |
| | Mercury | 3.70E-02 | RfD | 2.40E+01 | NO |
| | Nitrate | 8.95E+02 | RfD | 8.00E+05 | NO |
| | Selenium | 8.00E-01 | RfD | 2.40E+02 | NO |
| | Silver | 2.00E-01 | RfD | 2.40E+02 | NO |
| | TPH c/ | 1.13E+02 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.13
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 4
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 4
Medium Surface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SURFACE | Arsenic | 1.04E+01 | SF | 4.00E-01 | YES |
| SOILS | Barium | 8.02E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 1.50E+00 | RfD | 4.00E+01 | NO |
| | Chromium | 2.50E+01 | RfD | 4.00E+02 | NO |
| | Fluoride | 1.52E+02 | RfD | 4.80E+03 | NO |
| | Lead | 1.43E+02 | — | — | |
| | Mercury | 4.00E-02 | RfD | 2.40E+01 | NO |
| | Nitrate | 1.23E+03 | RfD | 8.00E+05 | NO |
| | Selenium | 1.00E+00 | RfD | 2.40E+02 | NO |
| | TPH c/ | 1.90E+02 | — | — | — |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH – total petroleum hydrocarbons.

TABLE 5.14
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 4
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 4
Medium Subsurface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SUBSURFACE | Arsenic | 6.90E+00 | SF | 4.00E-01 | YES |
| SOILS | Barium | 2.84E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 3.20E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.80E+01 | RfD | 4.00E+02 | NO |
| | Fluoride | 9.96E+01 | RfD | 4.80E+03 | NO |
| | Lead | 1.20E+01 | - | - | - |
| | Mercury | 3.50E-02 | RfD | 2.40E+01 | NO |
| | Nitrate | 1.39E+03 | RfD | 8.00E+05 | NO |
| | Selenium | 9.00E-01 | RfD | 2.40E+02 | NO |
| | Silver | 1.00E-01 | RfD | 2.40E+02 | NO |
| | TPH c/ | 7.55E+01 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH - total petroleum hydrocarbons.

detected arsenic concentrations are within the range of baseline concentrations reported for the region (see Section 5.2.4.3), and the likelihood of pathway completion is small. Therefore, Site 4 does not appear to pose a significant public health concern.

5.2.4.6 Site 5

Both ground water and soils were sampled at Site 5. No chemicals of concern exceeded their criteria in ground water (Table 5.15). As at other sites, the soils data were divided into surface and subsurface categories for analysis to accommodate exposure pathways. Only arsenic exceeded its criteria, both in surface and subsurface soils (Tables 5.16 and 5.17). However, a statistical analysis indicated that arsenic concentrations at Site 5 are not outliers and represent baseline conditions. In addition, arsenic is not associated with any identified contaminant sources at the site, and detected concentrations are similar to those detected regionally (Table 4.6 and Section 5.2.4.3). Therefore, detected concentrations of arsenic at Site 5 do not pose a significant public health concern.

5.2.4.7 Site 6

Ground water and soils were sampled at Site 6. No chemicals of concern exceeded their criteria in ground water (Table 5.18). Only subsurface soils were sampled at Site 6, and only arsenic exceeded its criteria in soils (Table 5.19). Because arsenic is not associated with any identified sources of chemicals of concern, and was not an outlier in the statistical analysis indicating baseline conditions, Site 6 does not appear to pose a significant public health concern.

5.3 PRELIMINARY ECOLOGICAL EVALUATION

This ecological evaluation uses the same basic methods as the preliminary human health evaluation. Chemicals of concern were selected based on the results of site sampling. Potential exposure pathways and receptors were identified, and the potential toxicity of chemicals of concern was evaluated.

5.3.1 Selection of Chemicals of Concern

The chemicals of concern selected for the ecological assessment are identical to those identified in the human health evaluation. The chemicals of concern evaluated in the ecological assessment were selected in a manner similar to that used in the human health evaluation.

5.3.2 Environmental Receptors

Nebraska ANGB is located in a former tall-grass prairie which is currently influenced by agricultural and urban uses. Habitat types occurring in the project area include tall-grass prairie, riparian woodland, wetland, and aquatic. Some plant and animal species known to occur in the project vicinity are described in Section 2.

Receptor organisms were identified by biological resource group based on those organisms likely to be present at individual locations. Receptor organisms were categorized as follows: wildlife, aquatic life, and vegetation. Species groups were identified at each of the six sites, and appropriate risk analyses were performed.

TABLE 5.15
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 5
Medium Ground Water

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Criterion Type Used a/ | Criterion Value (mg/L) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|--|------------------------|------------------------|---|
| GROUND | Arsenic | 2.50E-02 | MCL | 5.00E-02 | NO |
| WATER | Barium | 4.65E-01 | MCL | 1.00E+00 | NO |
| (Ingestion) | Fluoride | 1.00E+00 | MCL | 4.00E+00 | NO |
| | Nitrate | 1.50E+00 | MCL | 1.00E+01 | NO |

a/ MCL = maximum contaminant level.

b/ mg/L = milligrams per liter.

TABLE 5.16
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 5
Medium Surface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SURFACE | Arsenic | 2.60E+00 | SF | 4.00E-01 | YES |
| SOILS | Barium | 1.57E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 8.00E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.11E+01 | RfD | 4.00E+02 | NO |
| | Fluoride | 8.17E+01 | RfD | 4.80E+03 | NO |
| | Lead | 4.90E+00 | — | — | |
| | Mercury | 2.50E-02 | RfD | 2.40E+01 | NO |
| | Nitrate | 5.23E+02 | RfD | 8.00E+05 | NO |
| | Selenium | 7.00E-01 | RfD | 2.40E+02 | NO |
| | TPH c/ | 1.62E+02 | — | — | — |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH — total petroleum hydrocarbons.

TABLE 5.17
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 5
Medium Subsurface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SUBSURFACE | Arsenic | 3.80E+00 | SF | 4.00E-01 | YES |
| SOILS | Barium | 2.00E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 5.00E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.70E+01 | RfD | 4.00E+02 | NO |
| | Lead | 6.40E+00 | - | - | - |
| | Mercury | 2.50E-02 | RfD | 2.40E+01 | NO |
| | TPH c/ | 1.04E+02 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH - total petroleum hydrocarbons.

TABLE 5.18
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 6
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 6
Medium Ground Water

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Criterion Type Used a/ | Criterion Value (mg/L) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|--|------------------------|------------------------|---|
| GROUND WATER | Arsenic | 3.00E-03 | MCL | 5.00E-02 | NO |
| | Barium | 1.97E-01 | MCL | 1.00E+00 | NO |

a/ MCL = maximum contaminant level.

b/ mg/L = milligrams per liter.

TABLE 5.19
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH HEALTH CRITERIA AT SITE 6
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 6
Medium Subsurface Soils

| Exposure Medium | Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Criterion Type Used a/ | Criterion Value (mg/Kg) | Release Concentrations Exceed Criterion ? |
|-----------------|---------------------|---|------------------------|-------------------------|---|
| SUBSURFACE | Arsenic | 5.30E+00 | SF | 4.00E-01 | YES |
| SOILS | Barium | 1.93E+02 | RfD | 4.00E+03 | NO |
| (Ingestion) | Cadmium | 4.00E-01 | RfD | 4.00E+01 | NO |
| | Chromium | 2.50E+01 | RfD | 4.00E+02 | NO |
| | Lead | 9.50E+00 | - | - | - |
| | Mercury | 2.90E-02 | RfD | 2.40E+01 | NO |
| | TPH c/ | 8.49E+01 | - | - | - |

a/ SF = slope factor; RfD = reference dose.

b/ mg/Kg = milligrams per kilogram.

c/ TPH - total petroleum hydrocarbons.

5.3.2.1 Identification of Ecological Exposure Pathways

Receptors may be exposed to chemical contaminants through direct or indirect pathways. Direct pathways would include direct contact with or ingestion of contaminated media such as soil, sediment, or water. Indirect pathways include those in which an animal consumes other previously-contaminated organisms. If exposure pathways between contaminated media and receptor organisms are not complete, contaminants do not constitute an environmental risk.

Exposure media and routes may differ between various organisms due to their physiological and behavioral differences. For example, fish-eating birds may be exposed to contaminants by consuming fish that have bioaccumulated contaminants from surface water and sediments, whereas seed-eating birds may be exposed to contaminants from direct contact with soils, through incidental ingestion of soil while foraging, or from seeds that have accumulated contaminants through plant uptake from the soil. The following sections discuss in more detail the exposure pathways for each type of receptor.

Soil

Soil exposure pathways are potentially important for plants and wildlife at Nebraska ANGB. Terrestrial animals at the site may be directly and indirectly exposed to contaminants in the soil. Direct dermal contact with contaminated soil and incidental ingestion of soil could occur among burrowing animals or among dustbathing animals, such as many bird species. In general, information for quantifying and evaluating the toxicity of dermal exposures to wildlife species is limited.

Incidental ingestion of soil is also a possible exposure route: small mammals may ingest soil while grooming, herbivorous animals such as rabbits may ingest soil while feeding on plants, and seed-eating bird species may ingest soil while foraging for seeds on the ground. Indirect exposure to soil contaminants may occur through ingestion of soil-dwelling invertebrates (e.g., earthworms) or grasses and other plants which may bioaccumulate contaminants. As with other exposure pathways, the importance of this pathway varies from species to species because of behavioral differences. For example, populations of animals such as field mice, which are ground-dwelling animals and fastidious groomers, may be more greatly affected by contaminated soils than other species which contact soil less often.

Other exposures to soil contaminants, particularly for aquatic organisms, may result during rainfall when surface runoff can transport soil particles to nearby surface waters. Exposure to soil contaminants via this pathway is dependent upon such factors as the intensity of the storm (i.e., amount of rainfall), adsorption characteristics of the surface soils and the contaminants, the extent and type of vegetation covering the soil, and the degree of slope to the body of surface water. The potential for runoff at Nebraska ANGB is limited by man-made changes in the terrain. The fate and transport characteristics of the selected chemicals of concern are discussed in the human health evaluation (Section 5.2).

Plants may be directly exposed to contaminants in soil via uptake through their roots. Chemicals may accumulate in different plant tissues depending on the species. Because chemical uptake is known to vary between plant species and tissue, evaluating the potential impacts to plants is often difficult. However, plant phytotoxic criteria are relatively well documented.

Surface Water and Sediment

Surface water and sediment exposure pathways are combined in this discussion because environmental receptors exposed to one would almost certainly be exposed to the other. Aquatic organisms (e.g., fish, snails) may be directly exposed to contaminants in surface water and sediments. Of all sites sampled at Nebraska ANGB, only the Old Oak Creek channel (Site 2) provides aquatic habitat. This area may support some aquatic invertebrates such as snails, insects, and flatworms. The potential also exists for Old Oak Creek to overflow into Oak Creek, exposing additional offsite populations.

Most terrestrial wildlife species are dependent to some extent on surface water as a source of drinking water. Animals that use the Old Oak Creek channel for drinking water may be exposed to contaminants through ingestion. Some mammals living near the site may rely on Old Oak Creek as a primary source of drinking water. In addition to direct ingestion, terrestrial wildlife also may be exposed to contaminants in surface water through dermal contact while drinking or foraging for food.

Many chemicals are known to bioconcentrate in aquatic organisms. Because some terrestrial wildlife rely on aquatic organisms as a food source, these aquatic species may function as a source of contaminants to animals higher in the food chain. Omnivorous mammals such as raccoons, or birds such as ducks may be exposed through this pathway.

Exposure to chemicals present in sediments constitutes another possible exposure pathway for ecological receptors. In addition to benthic (bottom-dwelling) aquatic organisms who may be continuously exposed to contaminants in the sediment, wading birds and other animals may also be exposed to contaminants from direct contact with sediment while foraging for food. Aquatic plants may also be exposed to sediment contaminants through root uptake.

Ground Water

Ground water contaminants may constitute a risk to environmental receptors when utilized by plants, discharged by springs or wells to where animals may drink, and when surface waters are contaminated by ground water discharges. Pathways may be direct or indirect, and are most common where ground water depths are shallow.

Plants with roots extending below the water table may concentrate contaminants found in ground waters. This may cause direct phytotoxic effects to result. Similarly, the ingestion of contaminated drinking water may affect small and large mammals, birds, and all other organisms ingesting water derived from wells or springs.

5.3.3 Hazard Evaluation

A preliminary environmental evaluation was made for chemicals of concern at each of the six sites by comparing maximum detected concentrations to appropriate criteria for each receptor group. Available chemical-specific standards, criteria, and guidance for the protection of plants and animals are identified in Table 5.20 for the chemicals of concern. The references for each of the ecological criteria are also listed in the table. Promulgated values were used when available. For chemicals of concern without promulgated ecological criteria, values were selected from the literature that seemed to best apply to conditions at Nebraska ANGB. Criteria include Nebraska and EPA water quality criteria (for aquatic life and for livestock drinking water, and residues reported (RDS) for aquatic life and soil contaminant concentrations causing phytotoxic effects. The criteria shown in Table 5.20 were compared directly with maximum release concentrations at each site, by medium, to evaluate site-specific risks.

The following paragraphs describe the results of the risk evaluation for contaminated media at each site at the Nebraska ANGB. Because toxicity criteria are not available for all chemicals of concern, risks could not be evaluated in some cases.

5.3.3.1 Site 1

Ten chemicals of concern were identified in ground water and appear to be associated with fuel spills at Site 1. Assessments of the effects of ground water chemical concentrations on plants were not made because toxicity criteria for plant uptake of ground water are not available. It is possible that some plant roots at Site 1 extend below the water table; however, given the maximum detected values for the ten chemicals of concern at Site 1 and available plant toxicity literature for soils, there does not appear to be any immediate risk to plants at this site.

Maximum concentrations of chemicals of concern in ground water were compared to livestock drinking water criteria (Table 5.21). As Table 5.21 indicates, only nitrate concentrations exceeded livestock drinking water criteria. The State of Nebraska, Department of Environmental Control has indicated that concentrations of nitrate found in ground water at the base are similar to concentrations found throughout the state (Chambers, 1989). Because nitrate concentrations in ground water at Site 1 may represent baseline conditions, potential risks to animals drinking the ground water are not considered significant. However, ground water from Site 1 may discharge to Site 2, Old Oak Creek. Potential future concentrations in Old Oak Creek are unknown, but may pose a concern.

5.3.3.2 Site 2

Six chemicals of concern were identified in ground water sampled at Site 2. No assessment of the relationship between chemical concentrations and plant toxicity was made because toxicity criteria for plant uptake of ground water are not available. However, the detected chemical concentrations in ground water are generally indicative of background conditions. Therefore, no adverse effects to plant are expected.

TABLE 5.20
ECOLOGICAL CRITERIA
155th AIR REFUELING GROUP
LINCOLN AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical
of
Concern | Aquatic Life
Criterion
Value
(mg/L)a/ | Plant
Criterion
Value
(mg/Kg)b/ | Livestock
Drinking Water
Criteria
(mg/L) | References c/
(aquatic life, plant, livestock) |
|------------------------------|--|--|---|---|
| Arsenic | 4.80E-02 | 2.50E+01 | 2.00E-01 | 1,2,3 |
| Barium | 5.00E+01 | 2.00E+03 | — | 4,5,— |
| Benzene | 5.30E+00 | 5.25E+02 | — | 1,6,— |
| Benzo(a)anthracene | — | — | — | |
| Benzo(b)fluoranthene | — | — | — | |
| Benzo(k)fluoranthene | — | — | — | |
| Benzo(a)pyrene | — | — | — | |
| Bis(2-ethylhexyl)phthalate | 3.00E-03 | 2.00E+03 | — | 1,7,— |
| Cadmium | 6.60E-04 | 2.50E+00 | 5.00E-02 | 8,9,3 |
| Chromium | 1.00E-02 | 1.00E+02 | 1.00E+00 | 10,11,3 |
| Chrysene | — | — | — | |
| Ethyl benzene | 3.20E+01 | 1.90E+05 | — | 12,13,— |
| Fluoranthene | 3.98E+00 | — | — | 12,—,— |
| Fluoride | 2.00E+00 | 1.00E+02 | 2.00E+00 | 14,9,3 |
| Lead | 3.20E-03 | 1.20E+01 | 1.00E-01 | 19,15,3 |
| Mercury | 1.20E-05 | 3.00E-01 | 1.00E-02 | 4,16,3 |
| Nitrate | — | — | 1.00E+01 | —,—,17 |
| Phenanthrene | 3.00E-01 | — | — | 18,—,— |
| Pyrene | — | — | — | |
| Selenium | 3.50E-02 | 1.00E+01 | 2.00E-02 | 1,11,17 |
| Silver | 1.20E-04 | — | — | 1,—,— |
| Toluene | 1.75E+01 | — | — | 12,—,— |
| Total petroleum hydrocarbons | 1.00E+01 | — | — | 1,—,— |
| Xylenes | 3.60E+00 | — | — | 4,—,— |

a/ mg/L = milligrams per liter

b/ mg/Kg = milligrams per kilogram

c/ References:

1. Nebraska Department of Environmental Control (1989b).
2. Eisler (1988a).
3. National Academy of Sciences (1974).
4. U.S. Environmental Protection Agency (1986b).
5. Chaudry, Wallace, and Mueller (1977).
6. Clement Associates, Inc. (1985).

TABLE 5.20 (Continued)
ECOLOGICAL CRITERIA
155th AIR REFUELING GROUP
LINCOLN AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

7. U.S. Environmental Protection Agency (1980a).
8. U.S. Environmental Agency (1985).
9. U.S. Environmental Protection Agency (1980b).
10. Eisler (1986).
11. U.S. Environmental Protection Agency (1983a).
12. Nebraska Department of Environmental Control (1989a).
13. Sax (1987).
14. Christensen (1987).
15. Eisler (1988b).
16. Kabata-Pendias and Pendias (1984).
17. Nebraska Department of Environmental Control (1988b).
18. Neff (1985).
19. U.S. Environmental Protection Agency (1986a).

TABLE 5.21
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 1
155th AIR REFUELING GROUP
LINCOLN AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 1
Medium Ground Water

| Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion ? |
|---------------------|--|---|---|
| Arsenic | 4.80E-02 | 2.00E-01 | NO |
| Barium | 4.28E-01 | - | - |
| Benzene | 6.10E-01 | - | - |
| Ethyl Benzene | 1.10E+00 | - | - |
| Fluoride | 1.03E+00 | 2.00E+00 | NO |
| Nitrate | 1.92E+01 | 1.00E+01 | YES |
| Selenium | 1.70E-02 | 2.00E-02 | NO |
| Toluene | 4.20E-02 | - | - |
| TPH a/ | 9.14E+01 | - | - |
| Xylenes | 4.60E+00 | - | - |

a/ See Table 5.20.

b/ mg/L = milligrams per liter.

c/ TPH = total petroleum hydrocarbons.

Concentrations of chemicals of concern in ground water at Site 2 were compared with livestock drinking water criteria (Table 5.22). As Table 5.22 indicates, only nitrate exceeded its criteria. Because nitrate concentrations at the base are similar to those found throughout the state, potential risks to animals drinking ground water at Site 2 are not considered significant.

None of the six chemicals of concern identified in surface water at Site 2 exceeded criterion values for toxicity to aquatic life (Table 5.23). Therefore, surface waters in Old Oak Creek do not appear to pose a current threat to receptors in the creek or in the downgradient salt marsh. None of the six chemicals of concern exceeded the livestock drinking water criteria (Table 5.23), and therefore surface waters at Site 2 do not appear to pose a current threat to animals through ingestion. Because the detected chemical concentrations in surface water are generally indicative of background conditions, no adverse effects to aquatic plants are expected. However, because contaminated ground water at Site 1 has the potential to discharge into Old Oak Creek, surface water chemical concentrations should be monitored to insure that aquatic life and plants in the creek are not threatened.

Of the 20 chemicals of concern identified in sediment samples at Site 2, only lead and cadmium exceeded soil criterion values for phytotoxic effects on plants (Table 5.24). However, these metals are relatively immobile in sediments and generally unavailable for plant uptake. The phytotoxicity level for lead (12 mg/Kg) is based on the soluble lead fraction, whereas the recommended maximum acceptable concentration of total lead in soils is 1,000 mg/Kg (U.S. Environmental Protection Agency, 1983a). The maximum total lead concentration detected in Site 2 sediments was 92 mg/Kg.

5.3.3.3 Site 3

Six chemicals of concern were identified in ground water samples at Site 3. However, the relationship between ground water chemical concentrations and plant toxicity was not evaluated because toxicity criteria for plant uptake of ground water are not available. Concentrations of chemicals of concern were compared to livestock drinking water criteria (Table 5.25), and no criteria were exceeded. Ground water at Site 3, therefore, poses no apparent risks to animals.

Of the 11 chemicals of concern identified in surface soils at Site 3, only lead exceeded its criterion value for soils (Table 5.26). Soil lead is relatively immobile and unavailable to plants. In addition, lead concentrations did not exceed the phytotoxicity guideline for total lead in soils described in Section 5.3.3.2. A statistical analysis indicated that lead concentrations at Site 3 are reflective of baseline conditions (i.e. concentrations in site samples were not outliers). Therefore, surface soil lead concentrations represent a minimal threat to vegetation at Site 3.

Of 11 chemicals of concern identified in subsurface soil samples at Site 3, only fluoride exceeded the 100 mg/Kg fluoride toxicity criterion value for plants (Table 5.27). Elevated concentrations for fluoride onsite may be due to high regional background levels. Background fluoride concentrations in excess of 400 mg/Kg have been reported for the Lincoln, Nebraska region (Shacklette et al., 1974), and a

TABLE 5.22
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 2
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Releasing Unit | Site 2 |
|---------------------|--|---|---|
| | | Medium | Surface Water |
| | | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion ? |
| Arsenic | 4.00E-03 | 2.00E-01 | NO |
| Barium | 1.97E-01 | — | — |
| Chromium | 3.00E-03 | 1.00E+00 | NO |
| Fluoride | 5.20E-01 | 2.00E+00 | NO |
| Nitrate | 1.82E+01 | 1.00E+01 | YES |
| TPH c/ | 1.80E+00 | — | — |

a/ See Table 5.20

b/ mg/L = milligrams per liter

c/ TPH = total petroleum hydrocarbons

TABLE 5.23
COMPARISON OF SURFACE WATER CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 2
155th AIR REFUELING GROUP
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Release Unit Site 2
Medium Surface Water

| Chemical of Concern | Maximum Release Concentration (mg/L)b/ | Aquatic Criterion Value a/ (mg/L) | Release Concentrations Exceed Criterion ? | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion? |
|---------------------|--|-----------------------------------|---|---|--|
| Arsenic | 1.70E-02 | 4.80E-02 | NO | 2.00E-01 | NO |
| Barium | 1.41E-01 | 5.00E+01 | NO | — | — |
| Fluoride | 1.19E+00 | 2.00E+00 | NO | 2.00E+00 | NO |
| Nitrate | 2.70E+00 | — | — | 1.00E+01 | NO |
| Selenium | 5.00E-03 | 3.50E-02 | NO | 2.00E-02 | NO |
| TPH c/ | 1.60E+00 | 1.00E+01 | NO | — | — |

a/ See Table 5.20

b/ mg/L = milligrams per liter.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.24
COMPARISON OF SEDIMENTS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 2
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical of Concern | Maximum Release Concentration (mg/Kg)b/ | Releasing Unit | Site 2 |
|----------------------------|---|----------------------------------|---|
| | | Medium | Sediments |
| | | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
| Arsenic | 5.10E+00 | 2.50E+01 | NO |
| Barium | 1.28E+02 | 2.00E+03 | NO |
| Benzo(a)anthracene | 9.00E-01 | - | - |
| Benzo(a)pyrene | 8.40E-01 | - | - |
| Benzo(b)fluoranthene | 1.10E+00 | - | - |
| Benzo(k)fluoranthene | 8.90E-01 | - | - |
| Bis(2-ethylhexyl)phthalate | 2.50E+00 | 2.00E+03 | NO |
| Cadmium | 3.70E+00 | 2.50E+00 | YES |
| Chromium | 2.90E+01 | 1.00E+02 | NO |
| Chrysene | 1.30E+00 | - | - |
| Fluoranthene | 2.80E+00 | - | - |
| Fluoride | 7.50E+01 | 1.00E+02 | NO |
| Lead | 9.20E+01 | 1.20E+01 | YES |
| Mercury | 8.90E-02 | 3.00E-01 | NO |
| Phenanthrene | 2.50E+00 | - | - |
| Pyrene | 2.30E+00 | - | - |
| Selenium | 4.00E-01 | 1.00E+01 | NO |
| Silver | 2.70E+00 | - | - |
| Toluene | 4.50E-02 | - | - |
| TPH c/ | 2.91E+03 | - | - |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.25
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical of Concern | Maximum Release Concentration (mg/L) b/ | Releasing Unit | Site 2 |
|---------------------|---|---|---|
| | | Medium | Sediments |
| | | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion ? |
| Arsenic | 4.00E-03 | 2.00E-01 | NO |
| Barium | 3.09E-01 | — | — |
| Chromium | 5.00E-03 | 1.00E+00 | NO |
| Fluoride | 7.30E-01 | 2.00E+00 | NO |
| Nitrate | 5.10E+00 | 1.00E+01 | NO |
| Selenium | 1.00E-02 | 2.00E-02 | NO |

a/ See Table 5.20

b/ mg/L = milligrams per liter

TABLE 5.26
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 3
Medium Surface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 5.80E+00 | 2.50E+01 | NO |
| Barium | 2.04E+02 | 2.00E+03 | NO |
| Cadmium | 9.00E-01 | 2.50E+00 | NO |
| Chromium | 2.50E+01 | 1.00E+02 | NO |
| Fluoride | 7.39E+01 | 1.00E+02 | NO |
| Lead | 8.10E+01 | 1.20E+01 | YES |
| Mercury | 3.90E-02 | 3.00E-01 | NO |
| Nitrate | 9.87E+02 | - | - |
| Selenium | 3.00E-01 | 1.00E+01 | NO |
| Silver | 2.00E-01 | - | - |
| TPH c/ | 8.71E+01 | - | - |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram

c/ TPH = total petroleum hydrocarbons

TABLE 5.27
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 3
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 3
Medium Subsurface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 4.80E+00 | 2.50E+01 | NO |
| Barium | 2.16E+02 | 2.00E+03 | NO |
| Cadmium | 4.00E-01 | 2.50E+00 | NO |
| Chromium | 2.70E+01 | 1.00E+02 | NO |
| Fluoride | 1.37E+02 | 1.00E+02 | YES |
| Lead | 7.20E+00 | 1.20E+01 | NO |
| Mercury | 3.70E-02 | 3.00E-01 | NO |
| Nitrate | 8.95E+02 | — | — |
| Selenium | 8.00E-01 | 1.00E+01 | NO |
| Silver | 2.00E-01 | — | — |
| TPH c/ | 1.13E+02 | — | — |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

statistical analysis of inorganic chemical concentrations indicates that none were outliers at Site 3. Therefore, there does not appear to be a significant risk to vegetation due to site fluoride levels.

5.3.3.4 Site 4

Of the 10 chemicals of concern identified in surface soils at Site 4, fluoride and lead concentrations exceeded their plant criteria values (Table 5.28). Fluoride concentrations were within reported background concentrations for this region, and therefore do not appear to represent a risk to vegetation at Site 4. However, the maximum detected value for lead in soil at Site 4 was found to be an outlier in a statistical analysis and is probably a result of vehicular travel across the road surface. The level of risk depends on the plant species present, soil pH, root depth, and contaminant solubility. Soil lead is relatively immobile and its availability to plants may be limited. Furthermore, lead concentrations did not exceed the phytotoxicity guideline for total lead in soils described in Section 5.3.3.2, and plant growth along the gravel road would be impaired by the road surface and use.

Eleven chemicals of concern were identified in subsurface soil samples at Site 4. No plant criterion values for soils were exceeded (Table 5.29). The maximum detected lead concentration was approximately equal to the plant toxicity criterion value and probably does not indicate a substantial threat to roadside vegetation.

5.3.3.5 Site 5

Four chemicals of concern were identified in ground water at Site 5. However, chemical concentrations detected in ground water are generally indicative of background conditions. Therefore, no adverse effects to plants are expected. Concentrations of chemicals of concern were compared to livestock drinking water criteria (Table 5.30), and no criteria were exceeded. Ground water at Site 5 therefore poses no apparent risk to animals.

None of the 10 chemicals of concern identified in surface soils at Site 5 exceeded the toxicity criterion values for plants (Table 5.31). Therefore, there does not appear to be a threat to plants from surface soils at Site 5. Of the eight chemicals of concern identified in subsurface soils at Site 5, only fluoride exceeded the soil toxicity criterion (Table 5.32). The maximum detected fluoride concentration is within regional background concentrations and appears to represent site baseline concentrations according to the statistical outlier analysis. Therefore subsurface soils do not appear to pose a risk to vegetation.

5.3.3.6 Site 6

Two chemicals of concern were identified in ground water samples at Site 6. Comparisons between ground water concentrations and plant toxicity criteria could not be made because toxicity criteria for plant uptake of ground water are not available. However, chemical concentrations are generally indicative of background conditions. Therefore, no adverse effects to plants are expected. Concentrations of chemicals of concern were compared to livestock drinking water criteria (Table 5.33). No criteria were exceeded. Ground water at Site 6 therefore poses no apparent risk to animals.

TABLE 5.28
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 4
155TH AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 4
Medium Surface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 1.04E+01 | 2.50E+01 | NO |
| Barium | 8.02E+02 | 2.00E+03 | NO |
| Cadmium | 1.50E+00 | 2.50E+00 | NO |
| Chromium | 2.50E+01 | 1.00E+02 | NO |
| Fluoride | 1.52E+02 | 1.00E+02 | YES |
| Lead | 1.43E+02 | 1.20E+01 | YES |
| Mercury | 4.00E-02 | 3.00E-01 | NO |
| Nitrate | 1.23E+03 | - | - |
| Selenium | 1.00E+00 | 1.00E+01 | NO |
| TPH c/ | 1.90E+02 | - | - |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.29
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 4
155TH AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 4
Medium Subsurface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 6.90E+00 | 2.50E+01 | NO |
| Barium | 2.84E+02 | 2.00E+03 | NO |
| Cadmium | 3.20E-01 | 2.50E+00 | NO |
| Chromium | 2.80E+01 | 1.00E+02 | NO |
| Fluoride | 9.96E+01 | 1.00E+02 | NO |
| Lead | 1.20E+01 | 1.20E+01 | NO |
| Mercury | 3.50E-02 | 3.00E-01 | NO |
| Nitrate | 1.39E+03 | - | - |
| Selenium | 9.00E-01 | 1.00E+01 | NO |
| Silver | 1.00E-01 | - | - |
| TPH c/ | 7.55E+01 | - | - |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.30
COMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 5
Medium Groundwater

| Chemical of Concern | Maximum Release Concentration (mg/L) b/ | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion ? |
|---------------------|---|---|---|
| Arsenic | 2.50E-02 | 2.00E-01 | NO |
| Barium | 4.65E-01 | — | — |
| Fluoride | 1.00E+00 | 2.00E+00 | NO |
| Nitrate | 1.50E+00 | 1.00E+01 | NO |

a/ See Table 5.20.

b/ mg/L = milligrams per liter.

TABLE 5.31
COMPARISON OF SURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECONOMIC CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 5
Medium Surface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 2.60E+00 | 2.50E+01 | NO |
| Barium | 1.57E+02 | 2.00E+03 | NO |
| Cadmium | 8.00E-01 | 2.50E+00 | NO |
| Chromium | 2.11E+01 | 1.00E+02 | NO |
| Fluoride | 8.17E+01 | 1.00E+02 | NO |
| Lead | 4.90E+00 | 1.20E+01 | NO |
| Mercury | 2.50E-02 | 3.00E-01 | NO |
| Nitrate | 5.23E+02 | — | — |
| Selenium | 7.00E-01 | 1.00E+01 | NO |
| TPH c/ | 1.62E+02 | — | — |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.32
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 5
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Releasing Unit | Site 5 |
|---------------------|--|----------------------------------|---|
| | | Medium | Subsurface Soils |
| | | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
| Arsenic | 3.80E+00 | 2.50E+01 | NO |
| Barium | 2.00E+02 | 2.00E+03 | NO |
| Cadmium | 5.00E-01 | 2.50E+00 | NO |
| Chromium | 2.70E+01 | 1.00E+02 | NO |
| Fluoride | 1.17E+02 | 1.00E+02 | YES |
| Lead | 6.40E+00 | 1.20E+01 | NO |
| Silver | 2.00E-01 | - | - |
| TPH c/ | 1.04E+02 | - | - |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

TABLE 5.33
 OMPARISON OF GROUND WATER CHEMICAL CONCENTRATIONS
 WITH ECOLOGICAL CRITERIA AT SITE 6
 155th AIR REFUELING GROUP
 NEBRASKA AIR NATIONAL GUARD
 LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

| Chemical of Concern | Maximum Release Concentration (mg/L) b/ | Releasing Unit | Site 6 |
|---------------------|---|---|---|
| | | Medium | <u>Groundwater</u> |
| | | Livestock Drinking Water Criteria a/ (mg/L) | Release Concentrations Exceed Criterion ? |
| Arsenic | 3.00E-03 | 2.00E-01 | NO |
| Barium | 1.97E-01 | — | — |

a/ See Table 5.20.

b/ mg/L = milligrams per liter.

None of the seven chemicals of concern identified in subsurface soils at Site 6 exceeded toxicity criterion values for plants (Table 5.34). There does not appear to be a threat to plants from subsurface soils at Site 6.

5.4 UNCERTAINTY

There are several categories of uncertainties associated with this preliminary risk evaluation. All risk evaluations involve the use of assumptions, judgement, and imperfect data to varying degrees. Because of the preliminary screening nature of this evaluation, fewer assumptions (which could increase uncertainty) were used.

Uncertainty in a risk evaluation may arise for many reasons, including:

- Inadequate or inappropriate environmental chemistry sampling and analysis;
- Misidentification or failure to be all-inclusive in hazard identification;
- Use of maximum rather than upper (95th percentile) confidence interval for chemical concentration values;
- Choice of models or evaluation of toxicological data in dose-response quantification;
- Assumptions concerning exposure scenarios and population distributions for both human and environmental receptors; and
- Assumptions regarding future site conditions and land uses.

Uncertainty may be magnified in the evaluation through combination of these variables.

In risk evaluations, procedures are designed to be conservative in order that they may screen for risks that require additional study. The net effect of combining numerous conservative assumptions is that the final estimates of risk may be greatly overestimated, but will provide a guide for use in future studies, such as the RI, that more specifically estimate risks.

Environmental chemistry sampling and analysis error can stem from errors inherent in the sampling and analysis procedures, from a failure to take an adequate number of samples to arrive at sufficient areal resolution, from sampling and/or analysis errors, or from the heterogeneity of the matrix being sampled. One of the most effective ways of minimizing procedural or systematic error is to subject the data to a strict quality control review. Even with all data rigorously quality assured, however, there is still error inherent in all analytical procedures. Because of these limitations, it may not be possible to definitively determine if a sample is truly representative of site conditions.

The maximum concentrations of chemicals of concern at each of the six sites at Nebraska ANGB were compared to health and environmental criteria to evaluate the potential threat to identified receptors. This probably overestimates the threat to future receptors because attenuation and dispersion of chemicals of concern by natural processes may occur over time.

TABLE 5.34
COMPARISON OF SUBSURFACE SOILS CHEMICAL CONCENTRATIONS
WITH ECOLOGICAL CRITERIA AT SITE 6
155th AIR REFUELING GROUP
NEBRASKA AIR NATIONAL GUARD
LINCOLN MUNICIPAL AIRPORT, LINCOLN, NEBRASKA

Releasing Unit Site 6
Medium Subsurface Soils

| Chemical of Concern | Maximum Release Concentration (mg/Kg) b/ | Plant Criterion Value a/ (mg/Kg) | Release Concentrations Exceed Criterion ? |
|---------------------|--|----------------------------------|---|
| Arsenic | 5.30E+00 | 2.50E+01 | NO |
| Barium | 1.93E+02 | 2.00E+03 | NO |
| Cadmium | 4.00E-01 | 2.50E+00 | NO |
| Chromium | 2.50E+01 | 1.00E+02 | NO |
| Lead | 9.50E+00 | 1.20E+01 | NO |
| Mercury | 2.90E-02 | 3.00E-01 | NO |
| TPH c/ | 8.49E+01 | — | — |

a/ See Table 5.20.

b/ mg/Kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

In almost all risk evaluations, the largest source of uncertainty is in the development of comparison criteria. In environmental risk evaluations, toxicity thresholds vary considerably for different species. Because criteria are not available for all individual species, criteria for surrogate species must often be used. To compensate for this uncertainty conservative assumptions are used. This is necessary to account data gaps and gaps in toxicity information, and the great differences among species in contaminant uptake, bioaccumulation, and biomagnification of chemicals of concern. The resulting assessment therefore tends to overestimate risks. The toxicity of metals such as cadmium and lead to aquatic life is directly dependent on water hardness and alkalinity. Because this information was not available, toxicity criterion values had to be approximated and may not represent actual site conditions.

In the human health evaluation, health criteria for evaluating long-term exposures, such as RfDs or cancer slope factors, are based on concepts and assumptions which bias an evaluation in the direction of overestimation of health risk. These uncertainties are compensated for by using upper bounds for cancer potency factors for carcinogens and safety factors for RfDs for noncarcinogens. At best, the dose-response assumptions used in risk evaluation provide a rough but plausible estimate of the upper limit of risk. That is, it is not likely that the true risk would be much more than the estimated risk, but it could very well be considerably lower, even approaching zero.

In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical (Section 5.2.3.1). EPA's weight-of-evidence classification provides information which can indicate the level of confidence or uncertainty in the carcinogenicity data obtained from studies in humans or experimental animals. Some of the uncertainties in the hazard evaluation are further compensated for by assuming that animal carcinogens behave as human carcinogens.

There are also inherent uncertainties in identifying exposure scenarios for evaluation and in determining the exposure parameters that are combined with toxicological information to estimate risk. For example, there are uncertainties regarding assumptions in estimating the likelihood that an individual or environmental receptor would come into contact with chemicals of concern originating at the site, the concentration of chemicals in the environmental medium of concern, and the period of time over which such exposures might occur. In general, use of conservative assumptions in estimating exposure-point concentrations and estimating chemical intakes will result in a conservative evaluation.

Finally, because comparison criteria are not available for all chemicals of concern, certain potential health risks may be underestimated. For example, some PNAs are thought to be probable human carcinogens but no health-based criteria are yet available for this class of compounds.

5.5 SUMMARY

Ground water samples from Site 1 exceeded human health criterion values for benzene, nitrate, and selenium, and nitrate exceeded the livestock drinking water criterion value. Nitrate concentrations are similar to those found throughout the state (Chambers, 1989). The selenium in ground water appears to be derived from the soil, where it occurs naturally (Table 4.6 and Section 5.2.4.2). Benzene clearly exceeds its MCL and could pose a potential health concern if ground water is used as a drinking water source. Because of the evidence of ground water contamination by petroleum products, and because ground water migration may threaten the Old Oak Creek channel, additional investigation is recommended.

Site 2 had two chemicals of concern that exceeded human health criterion values. These included nitrates in the ground water and arsenic in sediments. Nitrate concentrations were higher at Site 2 than in the background well, but are similar to those found elsewhere in the state (Chambers, 1989). Arsenic concentrations are similar to regional soil concentrations (Table 4.6 and Section 5.2.4.3). Nitrate levels in ground water also exceeded livestock drinking water criteria. Cadmium and lead in sediments exceeded their respective plant toxicity criterion values, but lead did not exceed phytotoxicity guidelines for total lead in soils. These metals are relatively immobile in soils and are most likely unavailable for plant uptake. While risks to environmental receptors appear to be low at this time, there is a potential for migration of contaminants from Site 1 to Site 2. Therefore continued monitoring of Site 2 is recommended.

The only chemical of concern that exceeded its human health criterion value at Sites 3, 4, 5, and 6 was arsenic in soil samples. Arsenic is not associated with any identified sources of contaminants at Nebraska ANGB, was not an outlier in a statistical analysis performed to indicate baseline conditions except at Site 4, and is naturally occurring based on arsenic levels reported for the region (Table 4.6 and Section 5.2.4.3). Lead exceeded the plant toxicity criterion at Sites 3 and 4, but did not exceed phytotoxicity guidelines for total lead in soils. Lead is likely to be relatively immobile in site soils and probably does not represent a threat to plants. Fluoride exceeded the plant toxicity criterion at Sites 3, 4, and 5, but concentrations are naturally occurring based on their similarity to levels reported regionally by Shacklette et al., (1974) (Section 5.3.3.3). Because chemical concentrations at Sites 3, 4, 5, and 6 are low, and risks to human health or the environment are unlikely, no further investigation is recommended for these sites.

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

6.1.1 Site 1 - POL Storage Area

Site 1, the POL storage area, showed the highest degree of contamination and poses the greatest potential threat to human health and the environment. Measurable free product was observed in wells RW-2 and 1201. In addition, product films were noted in wells 1202 and 1203, and slight sheens were present in wells 0209 and 0216. Ground water samples were collected and analyzed. Dissolved chemicals of concern associated with free product included benzene, ethyl benzene, toluene, and xylenes. The extent of the plume of dissolved contaminants is larger than the area of detected free product; however, both dissolved chemicals and free product contamination appears to be localized in the vicinity of the tank farm. Levels of petroleum hydrocarbons detected in 1989 appear to have decreased since 1983, perhaps due to a combination of dilution, degradation, and operation of the product recovery system. Levels of common anions and metals in ground water were similar to levels observed in upgradient wells 0206 and 2-MW1. No soils samples were collected at Site 1.

Results of the risk evaluation show that benzene, nitrate, and selenium exceed their respective human health criteria in ground water. Nitrate in ground water also exceeded the livestock drinking water criterion at this site. Nitrate, often the result of agricultural practices, was detected at levels similar to those found throughout the state (Chambers, 1989). Selenium is a naturally-occurring element (see Table 4.6 and Section 5.2.4.2), and ground water concentrations are probably derived from the soil. Benzene poses a health risk only if ground water is used as a potable water source, which is unlikely due to its onsite location. Because Site 1 shows evidence of ground water contamination by petroleum products, both from the presence of free product and dissolved constituents, and because a southerly ground water migration direction appears to have brought the leading edges of the plumes into close proximity to the Old Oak Creek channel, additional investigations are recommended at Site 1.

6.1.2 Site 2 - Old Oak Creek Channel

Site 2, the Old Oak Creek channel, exhibits minimal contamination near storm drainage outfalls. Surface water, sediment, and ground water samples were collected from Site 2 and analyzed. Volatile and semivolatile organics were not

detected in the surface water samples, but low levels of petroleum hydrocarbons were detected at stations located downstream from Site 1. This suggests that ground water containing petroleum hydrocarbons is discharging into the creek at Site 1. Levels of common anions and metals in surface water were generally similar to those detected in upgradient wells 0206 and 2-MW1. At several stations located near storm drainage outfalls, levels were slightly higher.

PNAs, phthalates, and petroleum hydrocarbons were detected in stream sediments at Site 2. However, phthalates and PNAs are strongly adsorbed onto suspended particulates in bottom sediments and are typically found in most sediments throughout the world, including those not polluted by man. The EPA guideline of 100 mg/Kg for total PNAs in soils was not exceeded. Common anions and metals were also detected in sediments along the length of the stream. Levels of lead and cadmium exceeded phytotoxic levels for plants. However, these metals may be relatively immobile in the sediments and unavailable for uptake by aquatic plants. The phytotoxicity level for lead is based on the soluble lead fraction; the guideline for total lead was not exceeded.

Ground water quality in well 2-MW1 at Site 2 is generally indicative of background water quality, except that petroleum hydrocarbons were detected at concentrations slightly above the detection limit. Levels of anions and metals were similar to those detected in upgradient well 0206. Nitrate exceeded the MCL of 10 mg/L and livestock drinking water criteria in ground water, but the levels detected are similar to those found in ground water throughout the state (Chambers, 1989).

Old Oak Creek exhibits minimal contamination at outfalls, but appears to pose no immediate threat to human health or the environment. However, because of the potential for contaminated ground water at Site 1 to migrate into Site 2, continued monitoring of the Old Oak Creek channel located downgradient from Site 1 is recommended.

6.1.3 Site 3 - Former Tank Cleaning Area

At Site 3, the former tank-cleaning area, soils and ground water were sampled. Petroleum hydrocarbons were detected in soil borings, but were not detected in ground water samples. Metals and anions were detected in soil samples, but were within typical background ranges. The risk evaluation showed that arsenic in soils was the only chemical to exceed its health-based criteria. Arsenic is not associated with any site-related activities, and occurs at levels similar to those reported regionally (Table 4.6 and Section 5.2.4.3). Fluoride and lead exceeded plant phytotoxic levels in soils, however, the phytotoxicity guideline for total lead was not exceeded. Fluoride concentrations are similar to those reported for the region (Section 5.3.3.3). Both elements are expected to be relatively immobile in the environment and unavailable for plant uptake, and appear to be indicative of baseline conditions. Therefore, the potential for adverse health or environmental effects is low, and no further action is recommended.

6.1.4 Site 4 - South Rock Road

At Site 4, the access road, soil samples were collected. Petroleum hydrocarbons were detected, with the highest concentrations occurring at the 0- to 1-foot interval. This is probably due to past road spraying (dust control) activities and movement of motor vehicles across the road. Petroleum hydrocarbons are not particularly mobile in the soil, and would not be expected to migrate into the ground water.

Anion concentrations are within reported background ranges. Arsenic, barium, cadmium, and lead concentrations were highest at Site 4, and may not represent baseline conditions. However, the risk evaluation indicated that only arsenic levels in soils exceeded the human health criterion, and fluoride and lead exceeded their plant phytotoxic levels. Maximum site arsenic concentrations (10.4 mg/Kg and 6.9 mg/Kg in surface and subsurface soils, respectively) are similar to levels reported regionally (Table 4.6 and Section 5.2.4.3). Fluoride concentrations were within reported background concentrations for the region (Section 5.3.3.3), and only slightly exceeded the criterion for plants. Fluoride is not expected to be readily bioavailable. The lead criterion is based on the soluble fraction, and the phytotoxicity guideline for total lead in soils was not exceeded. The maximum detected value for lead in soils at Site 4 was found to be an outlier, which may indicate a low to moderate risk to vegetation at Site 4. However, lead levels decrease rapidly with depth, indicating that lead is relatively immobile in the soil and plant growth is inhibited by the road surface and use. Therefore, risks to human health and environmental receptors are low, and no further action is recommended.

6.1.5 Site 5 - Army National Guard Oil Storage Area

Soil and ground water samples were collected at Site 5, the Army National Guard Oil Storage Area. Petroleum hydrocarbons were detected in soil samples, but were not found in the ground water sample. Common anions and metals were detected in soil samples, but did not exceed background ranges. Levels of metals and anions detected in the ground water were comparable to levels detected in background wells 0206 and 2-MW1. The risk evaluation showed that arsenic in soils was the only chemical exceeding its human health criterion, and fluoride in soils exceeded its plant phytotoxic level. According to available baseline and historical data, both elements are naturally occurring. Because the small amounts of petroleum hydrocarbons in soils do not appear to be migrating, no further action is recommended for Site 5.

6.1.6 Site 6 - Hydraulic Fluid Spill Area

Three soil samples and one ground water sample were collected at Site 6. Petroleum hydrocarbons were detected in soil samples, but were not detected in the ground water sample. Levels of metals in soils and ground water were comparable to background levels. The risk evaluation showed that arsenic in soils was the only chemical exceeding its human health criteria. Arsenic is not associated with any site-related activities, was not an outlier in a statistical analysis of site samples, and is similar in concentration to regional levels (Table 4.6 and Section 5.2.4.3). No other criteria were exceeded. Therefore, no further action is recommended for this site.

6.2 RECOMMENDATIONS

Based on the information collected during the SI, no further action is needed at Sites 3, 4, 5, and 6. Contamination at Site 2 is presently at low levels which do not threaten human health or the environment. However, its proximity to Site 1 indicates that contaminant concentrations may increase in the future. Therefore, no further action is recommended for the upgradient portions of Site 2, and the lower portions are proposed for inclusion in Site 1. It is recommended that additional information be obtained for Site 1 through an extended SI. Recommended activities at Site 1 are listed below.

1. Recover existing free product to the extent possible utilizing existing monitoring and/or recovery wells.
2. Obtain additional information on existing monitoring and recovery wells. Currently, geologic logs and well construction information are available for 8 of 25 existing wells at Site 1. Additional information will allow further definition of geologic and hydrogeologic conditions for design of a remedial action program, and will help determine the suitability of the wells for continued use. If the information cannot be obtained from existing records, well depths can be determined using weighted probes, and a physical means of well probing can be employed to determine screened intervals.
3. Redevelop the existing monitoring wells. Due to the incomplete documentation for these wells, it is not known whether they were ever developed following their installation. Redevelopment will allow for greater confidence in results obtained from product thickness measurements, ground water quality sampling, and aquifer testing.
4. Obtain additional water level and product thickness measurements in existing wells to define seasonal variations. Data obtained from additional measurements will allow further quantification of the thickness of the free product layer, and will aid in design of a remedial system.
5. Install additional monitoring wells to better define the lateral extent of the dissolved contaminant plume, and perform supplemental ground water sampling in selected wells. A greater number of wells in the sampling program will allow for better definition of the extent and magnitude of dissolved contamination, and will guide the placement of a remedial system. Samples should be analyzed for total petroleum hydrocarbons and the VOCs benzene, toluene, ethyl benzene, and xylenes.
6. Perform slug tests in selected monitoring wells to provide more refined estimations of hydraulic conductivity. Such estimations will be necessary for design of a remedial action program.
7. Drill soil borings and collect soil samples from the unsaturated zone to define the extent and magnitude of soil contamination. Information obtained from soil sampling should help evaluate the necessity for remediation of soils in the unsaturated zone.

8. Install a limited number of monitoring well clusters, each consisting of one well screened entirely in the less-permeable clay horizon and one well screened entirely in the underlying sand. Hydrogeologic data obtained from Appendix D of the Hazardous Materials Technical Center report (1987) indicates that ground water was often first encountered in the upper, clayey unit during drilling of the existing wells, and that wells 0202 and 0209, which are screened entirely within the clayey zone, are water-bearing. In addition, the moderate to high fuel concentrations observed during drilling were located in the upper unit. In order to facilitate development of a remedial action program, water quality variations in the sand and clay layers, as well as the hydraulic characteristics of each of the horizons, should be investigated.
9. Collect additional soil samples in an area where no contaminant sources are known to exist to determine background concentrations of metals and anions.
10. Continue monitoring surface water quality in the Old Oak Creek channel at stations 2-SW4, 2-SW3, and 2-SW1. Surface water samples obtained from these stations should be analyzed for total petroleum hydrocarbons and the VOCs benzene, toluene, ethyl benzene, and xylenes. Periodic monitoring should provide data on the degree to which discharge of Site 1 ground water into the creek is affecting surface water quality.

The shallow ground water at Site 1 has little or no potential for use as a public or private drinking water supply. In such cases, the State of Nebraska ground water remedial action protocol (Title 118, Appendix A) requires cleanup of readily-removable contaminants (i.e., free product) and monitoring. It may also be necessary to set cleanup levels which protect streams from contaminated ground water discharge that would violate surface water standards. The recommended SI activities are designed to facilitate achievement of these remedial action objectives.

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APPENDIX A
GLOSSARY, LIST OF ACRONYMS AND ABBREVIATIONS,
AND UNITS OF MEASURE

APPENDIX A1

GLOSSARY

acute. A brief period of time during which an organism may be exposed to an elevated concentration or level of a substance which results in injury or mortality (e.g., 96 hours or less).

alluvial. Referring to alluvium (see alluvium).

alluvium. Unconsolidated terrestrial sediment composed of sorted or unsorted sand, gravel, silt, and clay deposited by river or stream actions.

analyte. The substance for which an analysis is conducted.

anion. A negatively-charged ion in solution.

anticline. A fold, generally convex upward, whose core contains the stratigraphically older rocks.

aquifer. A saturated permeable geologic unit that can transmit significant quantities of water under ordinary hydraulic gradients.

aquitard. A leaky confining bed that retards but does not prevent the flow of water to or from an adjacent aquifer.

bedrock. Solid rock in a natural position; may be exposed at the surface (outcrop) or overlain by unconsolidated strata.

bentonite. A sedimentary rock derived from volcanic ash, it is generally powdered or in pellets. Its ability to absorb water and swell makes it useful for sealing around well casings.

biodegradable. Compounds which can be decomposed into more elementary compounds or elements by the actions of microorganisms or other natural biological processes in the environment.

biotransformation. The altering of compounds in the environment into more elementary compounds or elements by the actions of microorganisms or other natural biological processes in the environment.

borehole. Any hole drilled for the purposes of obtaining geological information; generally using a tube with a hollow, cylindrical drill bit to collect the sample.

cancer. A disease characterized by the rapid and uncontrolled growth of aberrant cells into malignant tumors.

carcinogen. A chemical which causes or induces cancer.

carcinogenic slope factor. The additional risk of cancer posed by the ingestion of one milligram of a substance per kilogram of body weight per day over a lifetime.

CAS registration number. A number assigned by the Chemical Abstracts Service to identify a chemical.

cation. A positively charged ion in solution.

CERCLA. Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Primary federal legislation governing remedial action at past hazardous waste disposal sites.

chronic. An indefinite period of time during which an organism may be exposed to a concentration or level of a substance which results in adverse effects such as injury, mortality, reduced growth, or impaired growth (e.g., often one-tenth or more of the organism's life).

chronic toxicity. A condition in which exposure to a stimulus or toxic material continues for an extended time and typically induces a sublethal biological response.

critical habitat. The specific areas within the geological area occupied by a threatened or endangered species in which are found those physical or biological features essential to the conservation of the species, and which may require special management consideration or protection.

degradation. Chemical or biological breakdown of a complex compound into simpler compounds.

dermal exposure. Contact between a chemical and the skin.

downgradient. In the direction of decreasing hydraulic head; the direction in which ground water flows.

electrical conductivity. A numerical expression of the ability of an aqueous solution to carry an electric current; a general indication of dissolved solids (ions) in water.

endangered species. Any species which is in danger of extinction throughout all or a significant portion of its range.

fill. Material consisting of clay, silt, sand, and gravel with variable amounts of construction debris, concrete, asphalt, boards, and bar iron.

gas chromatograph (GC). An analytical instrument used for the quantification and identification of organic compounds.

ground water. Water beneath the land surface in the saturated zone.

hydraulic conductivity. Ratio of flow velocity to driving force for viscous flow of water under saturated conditions in soil or rock. Measure of the transmitting property of a material. The units are gallons per day per square feet (gpd/ft²) and it is the volume of water moving through a 1-foot-square cross sectional area in one day under a hydraulic gradient of one.

hydraulic gradient. Rate of change of pressure head per unit of distance of flow at a given point and in a given direction. Measure of the rate of change of water level elevation per unit of distance.

hydrogeology. The science that deals with the nature and distribution of aquifers and aquitards in a geologic system which are controlled by the lithology, stratigraphy, and structure of the geologic deposits and formations.

igneous rock. A rock formed by solidification of molten material.

ingestion. Type of exposure through the digestive tract.

inhalation. Type of exposure through the respiratory tract.

intermittent stream. A stream or reach of a stream that flows only at certain times of the year in response to precipitation or snowmelt.

isocontour. A designation of areas of equal geochemical concentration (e.g., salinity).

lithologic unit. A defined body of rock that is distinguished on the basis of physical characteristics and stratigraphic position.

lithology. The physical characteristics of a rock, such as color, type, mineralogic composition, and grain size.

lithostratigraphic classification. The organization of rock into units on the basis of their lithologic character.

maximum contaminant level (MCL). Enforceable standard for public drinking water supplies set by the EPA under the Safe Drinking Water Act.

metamorphic rock. A rock whose original mineralogy, texture, or composition has been changed by pressure, temperature, or the gain or loss of chemical components.

microgram (μg). One-millionth of a gram (10⁻⁶g; 3.5 x 10⁻⁸ oz. = 0.000000035 oz.).

milligram (mg). One thousandth of a gram (10⁻³g); (3.5 x 10⁻⁵ oz. = 0.000035 oz.).

nanogram (ng). One-billionth of a gram (10⁻⁹ grams).

oral. Of the mouth; through or by the mouth.

outlier. Data points outside the usual random fluctuations characterizing the population to which the data belong. Data are generally compared to plotting positions such as 95 percent confidence intervals.

paleostream. An ancient streambed, now buried beneath younger deposits.

perennial stream. A stream or reach of a stream that flows continuously throughout the year.

permeability. A measure of the relative ease of fluid flow through a porous medium. The Soil Conservation Service (1983) describes permeability qualitatively as follows:

| | |
|------------------|-------------------------|
| very slow | <0.06 inches/hour |
| slow | 0.06 to 0.2 inches/hour |
| moderately slow | 0.2 to 0.6 inches/hour |
| moderate | 0.6 to 2.0 inches/hour |
| moderately rapid | 2.0 to 6.0 inches/hour |
| rapid | 6.0 to 20 inches/hour |
| very rapid | >20 inches/hour |

pH. The negative \log_{10} of the hydrogen-ion activity in solution, a measure of the acidity or basicity of a solution.

photoionization detector. An instrument that detects and quantifies organic vapors.

plume. The extent of contaminated ground water within an aquifer.

polychlorinated biphenyl (PCB). A family of compounds varying widely in physical, chemical and biological properties, differentiated by the number of chlorine molecules.

polynuclear aromatic hydrocarbon (PNA). Fused-ring aromatic compounds, the simplest of which is naphthalene, then anthracene and phenanthrene. Several polynuclear hydrocarbons are known carcinogens.

porosity. The percentage of the total volume of a rock that is pore space (not occupied by mineral).

potency. Ability of a material to produce a given level of effect.

potentiometric surface. An imaginary surface representing the total head of ground water and defined by the level to which ground water will rise in a well.

product. Term used to describe any refined petroleum derivative.

purging. Evacuation of a minimum of three well-casing volumes of water from a well bore prior to sampling.

receptor. (1) In biochemistry, a specialized molecule in a cell that binds a specific chemical with high specificity and high affinity; (2) In exposure evaluation, an organism that receives, may receive, or has received environmental exposure to a chemical.

reference dose (RfD). The daily exposure level which, during an entire lifetime of a human, appears to be without appreciable risk on the basis of all facts known at the time.

riparian. Of, on, or pertaining to the bank of a water course.

risk. The potential or realization of unwanted adverse consequences or events.

shale. A fine-grained detrital sedimentary rock, formed by the consolidation of clay, silt, or mud.

sorption. The process of contacting a free fluid phase (gas or liquid) with a rigid and durable particulate phase which has the property of selectively taking up and storing one or more solute species originally contained in the fluid. The solute can be taken up onto the particulate surfaces (adsorption) or into the particulate material (absorption).

stratigraphy. The arrangement of strata, especially as to geographic position and chronologic order of sequence.

syncline. A fold of which the core contains the stratigraphically younger rocks; it is generally concave upward.

synergism. An interaction of two or more chemicals that results in an effect that is greater than the sum of their effects taken independently.

threatened species. Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

toxicity. The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

toxicity assessment. Characterization of the toxicological properties and effects of a constituent, including all aspects of its absorption, metabolism, excretion and mechanism of action, with special emphasis on establishment of dose-response characteristics.

unconfined aquifer. An aquifer in which the water table forms the upper boundary.

upgradient. In the direction of increasing hydraulic head; the direction opposite to the prevailing flow of ground water.

volatile. Readily vaporizable at a relatively low temperature.

well development. Evacuation of a minimum of up to 10 volumes of water from the well casing, or until the water becomes clean and the field parameters (temperature, pH, and electrical conductivity) have stabilized.

APPENDIX A2

LIST OF ACRONYMS AND ABBREVIATIONS

| | | |
|-------------------------------|---|--|
| Ag | - | Silver |
| ANG | - | Air National Guard |
| ANGB | - | Air National Guard Base |
| ARAR | - | Applicable or Relevant and Appropriate Requirement |
| As | - | Arsenic |
| AVGAS | - | Aviation gas |
| Ba | - | Barium |
| BFB | - | Bromofluorobenzene |
| C | - | Carbon |
| CCC | - | Calibration check compound |
| CCV | - | Continuing calibration validation |
| C ₂ H ₂ | - | Ethyne (acetylene) |
| CAG | - | Carcinogen assessment group |
| CAS | - | Chemical Abstracts Service |
| Cd | - | Cadmium |
| CERCLA | - | Comprehensive Environmental Response,
Compensation, and Liability Act |
| CFR | - | Code of Federal Regulations |
| Cl | - | Chloride |
| CLP | - | Contract Laboratory Program |
| CLPM | - | Contract Laboratory Program Method |
| COC | - | Chain of custody |
| Cr | - | Chromium |
| Cr(OH) ₃ | - | Chromium Hydroxide |
| CRAVE | - | Carcinogen Risk Assessment Verification Endeavor |
| CRDL | - | Contract-required detection limit |
| CRQL | - | Contract required quantitation limit |
| DFTPP | - | Decafluorotriphenylphosphine |
| DL | - | Detection Limit |
| DOD | - | U. S. Department of Defense |
| DOE | - | U. S. Department of Energy |
| DRMO | - | Defense Reutilization and Marketing Office |

APPENDIX A2 (continued)
LIST OF ACRONYMS AND ABBREVIATIONS

| | | |
|------------------|---|--|
| E | - | East |
| EC | - | Electrical conductivity |
| Eh | - | Oxidation potential |
| Energy Systems | - | Martin Marietta Energy Systems |
| EPA | - | U.S. Environmental Protection Agency |
| ES | - | Engineering-Science, Inc. |
| F | - | Fluoride |
| FS | - | Feasibility Study |
| GC | - | Portable gas chromatograph |
| GFAA | - | Graphite furnace atomic absorption |
| GPC | - | Gel permeation chromatograph |
| HAS | - | Hazard assessment score |
| HAZWRAF | - | Hazardous Waste Remedial Actions Program |
| Hg | - | Mercury |
| HNO ₃ | - | Nitric acid |
| HPLC | - | High-pressure liquid chromatography |
| IADS | - | Inorganics analysis data sheet |
| ICP | - | Inductively-coupled plasma |
| ICV | - | Initial calibration validation |
| IDL | - | Instrument detection limit |
| IRIS | - | Integrated Risk Information System |
| IRP | - | Installation Restoration Program |
| IS | - | Internal standard |
| LC | - | Lethal concentration |
| LD | - | Lethal dose |
| MCL | - | Maximum Contaminant Level |
| MS | - | Mass spectrometer |
| MSA | - | Method of standard addition |
| msl | - | Mean sea level |
| N | - | North; nitrogen |
| Na | - | Sodium |
| NAAQS | - | National Ambient Air Quality Standards |

APPENDIX A2 (continued)
LIST OF ACRONYMS AND ABBREVIATIONS

| | | |
|-----------------|---|---|
| NCP | - | National Contingency Plan |
| ND | - | Not detected; not determined |
| NGB | - | National Guard Bureau |
| NH ₃ | - | Ammonia |
| NH ₄ | - | Ammonium |
| No., # | - | Number |
| NO ₂ | - | Nitrite |
| NO ₃ | - | Nitrate |
| NPDES | - | National Pollutant Discharge Elimination System |
| NPL | - | National Priorities List |
| OADS | - | Organics analysis data sheet |
| PA | - | Preliminary Assessment |
| PAH | - | Polycyclic aromatic hydrocarbon |
| Pb | - | Lead |
| PCB | - | Polychlorinated Biphenyl |
| P.E. | - | Professional Engineer |
| Percent D | - | Percent difference |
| P.G. | - | Professional Geologist |
| PNA | - | Polynuclear aromatic hydrocarbons |
| POL | - | Petroleum, Oils, and Lubricants |
| PR | - | Percent recovery |
| PVC | - | Polyvinyl chloride |
| QA | - | Quality Assurance |
| QC | - | Quality Control |
| R | - | Range |
| RA | - | Remedial Action |
| RCRA | - | Resource Conservation and Recovery Act |
| RD | - | Remedial Design |
| RfD | - | Reference dose |
| RI | - | Remedial Investigation |
| RI/FS | - | Remedial investigation and feasibility study |
| RPD | - | Relative percent difference |

APPENDIX A2 (continued)
LIST OF ACRONYMS AND ABBREVIATIONS

| | | |
|-----------------|---|--|
| RRF | - | Relative response factor |
| RSD | - | Residues reported |
| S | - | South |
| SARA | - | Superfund Amendments and Reauthorization Act |
| SD | - | Standard deviation |
| Se | - | Selenium |
| Sect. | - | Section |
| SF | - | Slope Factor |
| SI | - | Site Inspection |
| SO ₄ | - | Sulfate |
| SPCC | - | System performance check compound |
| T | - | Township |
| TRG | - | Tactical Reconnaissance Group |
| TCL | - | Target compound list |
| TKN | - | Total Kjeldahl nitrogen |
| TPH | - | Total petroleum hydrocarbons |
| U.S. | - | United States |
| VOC | - | Volatile organic compound |
| W | - | West |
| WQC | - | Water quality criteria |

APPENDIX A3

UNITS OF MEASUREMENT

af - acre feet
atm - atmospheres
atm-m³/mole - atmospheres (meters cubed) per mole
C - celcius or centigrade
cfs - cubic feet per second
cm - centimeter(s)
cm/s - centimeters per second
d - day
F - Farenheit
ft, ' - feet
ft/day - feet per day
ft/ft - feet per foot
ft/yr - feet per year
g - gram(s)
g/day - grams per day
gpd - gallons per day
gpd/ft - gallons per day per foot
gpd/ft² - gallons per day per square foot
Kg - kilograms
Kg/yr - kilograms per year
K_{oc} - organic carbon partition coefficient
L - liter(s)
L/day - liters per day
L/Kg/day - liters per kilogram per day
mg/Kg - milligrams per kilogram
mg/Kg/day - milligrams per kilogram per day
mg/L - milligrams per liter
mL - milliliter(s)
mL/g - milliliters per gram
mm - millimeter(s)
mm Hg - millimeters of mercury
ng - nanogram(s)

APPENDIX A3 (continued)
UNITS OF MEASUREMENT

oz - ounce

s - second

\bar{x} - mean

yr - year

$\mu\text{g/Kg}$ - micrograms per kilogram

$\mu\text{g/L}$ - micrograms per liter

$\mu\text{g/m}^3$ - micrograms per cubic meter

$\mu\text{mhos/cm}$ - micromhos per centimeter

% - percent

° - degrees

°C - degrees Celcius or degrees centigrade

°F - degrees Farenheit

" - inches